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Dyna-METRIC Version 5

A Capability Assessment Model Including Constrained Repair and Management Adaptations

Karen E. Isaacson, Patricia Boren

August 1988

40 Years
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Dyna-METRIC Version 5 is a capability assessment model that relates logistics resources and policies to wartime readiness. This report, intended for users of the Version 5 Dyna-METRIC model, describes the model's motivation, capabilities, use, and methodology. Version 5 was developed to more accurately represent the uncertainty in demand and repair, especially queueing and unanticipated demands. It is expressly suited to analysis of the effect of constraints on resources in the context of aircraft components and to evaluation of ways to overcome these constraints.

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A Project AIR FORCE report
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United States Air Force

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PREFACE

The RAND Corporation has developed new analytic methods for studying the transient behavior of component-repair/inventory systems under time-dependent operational demands and logistics decisions like those that might be experienced in wartime [1]. These methods have undergone a series of extensions and contractions that culminated in the Dyna-METRIC model described here.

Dyna-METRIC evolved through a series of projects at RAND that addressed the evaluation of alternative policies for improving readiness and sustainability. Version 3.04 was the first Dyna-METRIC model released as a standard version [2]. An analytic model, it encompassed dynamic queueing equations, aircraft availability performance measures, multiple bases of aircraft and their dependence on transportation of spare parts, and centralized repair and resupply capability.

Dyna-METRIC was further extended to better represent the wholesale system, deriving demands for repair and supply at the depots from the dynamics of the flying program at the operating bases and predicting the operational performance of the bases given the resources and policies at the depot. This was done under the "Wartime Sustainability Project" for the Office of the Secretary of Defense.

A complete redesign of the model was supported by the "Improving Readiness Assessment and Management Study" under Project AIR FORCE. Released as Version 4, the redesign extended Dyna-METRIC to include worldwide assessments of how logistics functions and echelons interact to enhance or constrain wartime capability [3]. Major enhancements included substantially more detail in the description of component pipelines (because of a further level of component indenture and an additional echelon of component repair and supply) and expanded report capabilities. The Management Sciences Division (XPS) of the Air Force Logistics Command at Wright-Patterson AFB is currently responsible for this version.

Version 4 did not adequately represent the uncertainties in the removal and repair processes, nor did it indicate how the logistics system might cope with those uncertainties. Version 5 was developed to more accurately portray repair resource constraints and the management adaptations in the repair and distribution processes that might mitigate the effect of those constraints. Because of the detailed behaviors being modeled, Version 5 uses Monte Carlo sampling to compute probabilities, rather than Palm's theorem [4, 1] as its predecessors did.

This report is intended for users of the Version 5 Dyna-METRIC model. It provides a comprehensive description of the model's motivation, capabilities, use, and methodology. It was prepared as part of the Project AIR FORCE Resource Management Program, specifically the studies of "Improving Readiness Assessment and Management" and "Enhancing the Integration and Responsiveness of the Logistics Support System to Meet Wartime and Peacetime Uncertainties," commonly known as the "Uncertainty Project."

SUMMARY

Dyna-METRIC Version 5 is a capability assessment model that **relates logistics resources and policies to wartime readiness.** Developed for logisticians to improve wartime logistics support, the various versions of Dyna-METRIC assess the effects of wartime dynamics and repair constraints and provide operational performance measures.

Version 5 was developed because earlier versions did not accurately represent the uncertainty in demand and repair, especially the queueing caused by repair constraints, nor the actions management might take to overcome unanticipated demands. As we know from studies of the demand process [5, 6], the mean removal rate for components and the variation about that mean change over time and are difficult to predict. There will undoubtedly be more removals than expected for some components and fewer for others. Spending more money on more spares is not necessarily a satisfactory protection against uncertainty, because it is difficult to know which components will require the extra spares. A better strategy for coping with uncertainty might be to use more flexible resources, such as repair or lateral supply. **Version 5 is expressly suited to analyzing the effect of constraints on these resources in regard to aircraft components and to evaluate actions for overcoming these constraints.**

In evaluating options in the repair and distribution processes that are available to management, the model represents three echelons of activity, including the depot-to-theater link. Output reports reflect the performance of each base for the set of components assigned to each repair resource with a full-cannibalization assumption and indicate which component shortages cause the most not fully mission capable (NFMC) conditions (and how frequently).

Despite its improvement in representing constrained repair, Version 5 lacks several features of the earlier Dyna-METRIC models. Perhaps the most important feature omitted is the representation of subcomponents (parts that are indentured to components). In effect, Version 5 assumes adequate stock levels of subcomponents so that component repair is never delayed because of a shortage of subcomponents. The potential effect of such shortages should not be ignored. Subcomponents will be reintroduced when another version of the model is developed. Also omitted from Version 5 are the computation of spares requirements and the extensive problem parts diagnosis.

Structurally, Version 5 is similar to earlier versions, but Monte Carlo sampling has replaced the analytic computation of probabilities based on extensions of Palm's theorem [4, 1]. The model's architecture resulted from the desire to maintain consistency with previous versions' world views and the need for efficiency in execution.

Sample analyses using eight F-16 avionics components that are tested on the CI (computer/inertial) repair resource illustrate the use of Version 5.

Additional features are available for analyzing automatic test equipment, a type of repair resource that experiences frequent failures that can render it incapable of fixing some of its assigned components. The model represents this failure process in two ways. The first handles failures that render the resource incapable of repairing anything at all. The second handles those that leave it capable of repairing only some components. Because the data requirements for the second representation are detailed and difficult to satisfy from standard data collection systems, a preprocessor has been developed that transforms more usual data into that required by Version 5.

The appendixes provide details on using the model. Of particular note are the pipeline file formats and input specifications for the model and the preprocessor.

ACKNOWLEDGMENTS

Many RAND analysts have contributed to the development of Dyna-METRIC Version 5. Raymond Pyles provided ideas and assistance in determining the scope of the constrained repair model. David Pyke provided the initial implementation of the scheduling algorithm based on future aircraft availability. James Guyton, Louis Miller, and James Hodges helped with the random number generator. Jack Abell, Irv Cohen, and Thomas Lippiatt provided encouragement, support, and guidance. Christopher Tsai helped formulate the constrained repair model based on his extensive knowledge derived during the construction of Dyna-SCORE. We thank him for his help and advice during the debugging phase and for briefing this model to countless audiences. Both he and Louis Miller improved this report with their careful reviews.

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GLOSSARY

AWP (awaiting parts): a repair status indicating that a component's repair cannot continue until one or more serviceable subcomponents become available.

cannibalization: the practice of transferring a serviceable component from one aircraft to repair another. The donor aircraft must already be unserviceable because of another component failure, and the needed serviceable component must be currently unavailable from local supplies.

CIRF (centralized intermediate repair facility): a shop that repairs components from one or more bases.

constrained repair: a status of repair resources indicating that the repair facility is limited such that an arriving component joins a queue of other components also awaiting service.

FCFS (first come, first served): a repair process whereby the first component arriving for repair is the first to be serviced.

FMC (fully mission capable) aircraft: an aircraft that has all LRUs functional and none broken.

FMC server: a server that can repair all of its assigned LRUs.

LRU (line replaceable unit): a component typically removed from the aircraft at the flight line, rather than in a back shop.

NFMC (not fully mission cable) aircraft: an aircraft with one or more broken LRUs that degrade its ability to accomplish its wartime mission.

NMC server: a server that can repair none of its assigned LRUs.

NRTS (not reparable this station): a status indicating that a component cannot be repaired at a specified facility.

pipeline: a network of repair and transportation processes through which reparable and serviceable parts flow as they are removed from their higher assemblies, repaired, and requisitioned from other points of supply.

pipeline segment: a single process in the pipeline characterized by part arrivals over time, a delay time, and part departures over time.

PMC server: a server that can repair some but not all of its assigned LRUs.

unfilled requisition: an asset requested by a location but not yet shipped in response to the request.

VTMR: variance-to-mean ratio.

I. INTRODUCTION

The Dyna-METRIC model provides information that can be used to improve wartime logistics support. The various versions produce operational performance measures, capability assessments, and problem detection and diagnosis. This report describes Version 5, a capability assessment model designed specifically to analyze the effects of constrained repair and evaluate management alternatives that might mitigate these effects.

Earlier versions of Dyna-METRIC have been adopted as standard assessment tools within the Air Force. For instance, the Air Force Logistics Command's Weapon System Management Information System (WSMIS) uses the model to produce assessments of both planned and actual stock support in standard, single theater operations [7]. The model currently being integrated into WSMIS is Version 4 [3], which provides worldwide assessments of how the logistics functions and echelons interact to enhance or constrain wartime capability.

The earlier versions of the model did not accurately represent the uncertainty in demand and repair, especially the queueing caused by repair constraints, or the actions management might take to overcome unanticipated demands. As we know from studies of the demand process [5, 6], the mean removal rate for components and the variation about that mean change over time and are difficult to predict. Undoubtedly, there will be more removals than expected for some components and fewer for others. Spending more money on more spares is not necessarily a satisfactory protection against uncertainty, because it is difficult to know which components will require the extra spares. A better strategy might be to use more flexible resources, such as repair and/or lateral supply. Version 5 was developed to analyze the effects of constraints on these resources in regard to aircraft components and to evaluate actions for overcoming these constraints.

Such analyses are important. Wartime demands are likely to overwhelm some key repair resources of the logistics system. Assuming adequate resources, as in the earlier versions of the model, leads to overestimation of force capability. But the logistics system will probably react to such stresses to reduce their effect. Thus Version 5 also considers mitigating options in the repair and distribution processes that are available to management, such as lateral supply (shift assets among bases to those in the worst shape) and priority repair scheduling (repairing most urgently needed components first).

Version 5 is loosely based on the analytic Version 4, but it uses Monte Carlo sampling, instead of Palm's theorem, to predict pipeline contents. The structure of the earlier version was retained, permitting an expeditious development.

The change from an analytic approach using Palm's theorem to Monte Carlo sampling was made for two reasons. First, management adaptations in repair and distribution priorities could not be addressed using Palm's theorem. Second, some of the assumptions required in order to use Palm's theorem limited the model's ability to accurately represent the logistics system.

One assumption was that of ample servers: If a component needed a repair resource such as a set of test equipment, the resource was immediately available. There was no queueing delay for repair, leading to the overestimation of force capability in cases where there were indeed inadequate repair resources.

Version 4 attempted to address this problem by using an expected value simulation. This approach accounted for some of the queueing associated with resource constraints; it captured

the first order effects due to expected repair demands and resource availability. But it did not account for the variance in demands. As a result, the expected queue size was underestimated (in an extreme example, the model predicted no queue at all, whereas queueing theory predicts an expected queue building over time to infinity). Also underestimated was the variance of the queue, hence the variance of the component's pipeline.

Even if we had solved the queueing problem within Version 4 and had been able to compute pipeline distributions accurately in the face of resource constraints, the assumption that component pipeline contents are independent would still have proven troublesome. One implication of this was that knowledge of the size of one component's pipeline provided us with no information about the size of the other components' pipelines. With priority repair, such an assumption is not true. The priority repair scheme attempts to level all the components' pipelines, introducing some degree of correlation. By taking the true pipeline probability distributions and treating them as if they were independent, we would underestimate available aircraft.

Monte Carlo sampling enables us to relax the ample server and independence assumptions. The effect of limited repair resources on the mean and variance of the components' queues and pipelines is more accurately computed. The interaction between the components' pipelines is also correctly portrayed, resulting in more reliable performance predictions.

This report describes Version 5 primarily for the potential user or analyst. Section II gives a brief overview of the logistics system we are modeling. Section III discusses the model's capabilities, extensions, and limitations. Section IV explains how the model works. Section V demonstrates the use of the new features, showing how to set up the input data and what reports are produced. Section VI describes the model's portrayal of repair resource unreliability, including the data needed, and how a special preprocessor can be used to compute the data (which are frequently not available from standard sources).

II. OVERVIEW OF THE LOGISTICS WORLD

Dyna-METRIC models the logistics system that provides support to aircraft. Although this material describes the model's view of the Air Force world and deals with aircraft, the model can be used to analyze such other weapon systems as helicopters and tanks.

THE SCENARIO

The model represents one or more types of aircraft at one or more bases located in one or more theaters of operations for a period of time that may range from several days to several years. The model predicts the effect of the logistics support system on the bases' ability to execute their assigned flying programs.

The operating locations to which aircraft are assigned may be permanent bases or temporary facilities to which the aircraft have been deployed. Aircraft can operate out of a base on a fly-out, fly-back program (as fighter aircraft typically do) or on a fly-in, fly-out program (as cargo aircraft do when flying a circuit). Broken parts appear when aircraft land. Removals of failed components may be more likely at some bases than at others.

Different bases can support different types of aircraft. An analyst can model a real base supporting several aircraft types by locating each type at different bases served by a common, centralized intermediate repair facility (CIRF) with instantaneous connections.

The flying programs to be executed by the various bases may vary over time. The number of aircraft can increase with the deployment of new units and decrease from attrition or reassignment of aircraft. The number and length of sorties may vary each day, as can the maximum single aircraft sortie rate, which limits the number of sorties that one operational aircraft can fly in a single day. With this flexibility, the model can accommodate most conceivable flying programs, including typical peacetime and wartime scenarios.

THE AIRCRAFT

Aircraft are assumed to have an indentured component structure; an aircraft is composed of line replaceable units (LRUs) that are composed of shop replaceable units (SRUs). Version 4 models LRUs SRUs, and a lower indenture that we call subSRUs. Version 5 deals only with aircraft and LRUs.

Aircraft availability is modeled as a direct function of the availability of the aircraft's LRUs. A given type of LRU may appear on an aircraft one or more times. A hole, or shortage of an LRU, causes the aircraft to be not fully mission capable (NFMC) or partially mission capable (PMC). At each base, holes are assumed to be consolidated into the fewest possible number of aircraft—a policy of full cannibalization.

The model accommodates the possibility that there may be differences in the components on the aircraft at a single base. Such a situation may arise when components are being phased in or out, or when some of the aircraft are specially equipped.

THE REPAIR AND DISTRIBUTION SYSTEM

The logistics component support system is assumed to be a five-echelon hierarchical structure: Flight lines (from which aircraft operate) are supported by local base repair shops, which are supported by CIRFs, which are supported by depots, which may be supported by various suppliers of components. Not all echelons are required. For example, the CIRF level of logistics support could be omitted (thereby connecting bases directly with depots), or depots could be omitted (connecting bases and CIRFs directly to the suppliers).

Reparable components essentially move upward in this hierarchy. Reparable parts are removed from the aircraft at the flight line and serviced at base level. If not reparable there, they are transported to a CIRF and serviced. If not repaired there, they are sent on to the depot. Stocks of serviceable spare parts may be held at any echelon, and over time these serviceable spares are sent down the hierarchy to replace the reparable ones that have been sent up.

The repair capabilities of each echelon can be modeled in considerable detail. Repair for LRUs may be unconstrained, where maintenance is assumed to begin as soon as a component arrives at a repair facility; or it may be constrained, where an arriving component joins a queue of other components also awaiting service. How long a component waits for service depends on how heavily loaded the repair facility is and on the scheduling policy in use.[1] Basically, the repair process is single stage, which may not be a good representation for some components.

A repair facility may have several types of repair resources, each of which repairs a different set of LRU types. An individual station, or server, can test/repair at most one LRU at a time. For example, an avionics shop might have multiple servers of the computer/inertial repair resource that tests and repairs inertial navigation units, among other components. The number of servers at the various locations may change over time, which facilitates the modeling of deploying units and the mobilization of repair facilities for wartime operations. Repair capabilities may also change over time because of the unreliability of the repair facility itself.[2]

Inherent in Dyna-METRIC is a worldwide perspective. Demands for repair at the depot may arrive from several types of aircraft flying in several different theaters. The depot's repair facilities and spare stock pools are effectively shared across all forces served by the depot.

Dyna-METRIC portrays component support processes as a network of pipelines through which components flow as they are repaired or replaced. Arriving components must spend a (random or deterministic) delay time in each pipeline segment. Some delay times, such as local repair times, vary by component; others, such as intratheater transportation times, depend on the base being assessed. There may also be instances when components are "frozen" in their segments and do not flow, as in the transportation segment when a transportation cutoff is in effect.

Failed components enter the pipeline network at the bases' flight lines. Each base has several aircraft; their use generates component failures and thus demands for replacement components. Each base has a flight line support capability that removes and replaces those components, drawing serviceable spares from local supply as needed to repair aircraft.

A base may also have component repair shops that test failed components and return them to serviceable condition. For units deploying to new bases, that repair capability may be available only after some delay, while the repair facility is being deployed and set up.

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[1]Scheduling policies are discussed in Sec. III.

[2]Unreliability of repair facilities is discussed in Sec. VI.

Once components are removed from the aircraft, they are repaired at local shops or sent to other facilities. Items repaired locally are returned to local stock. Items declared not reparable this station (NRTS) are sent to repair facilities at a higher echelon while replacements are ordered from there. Upon receiving a requisition, the repair facility immediately sends a serviceable spare if available, or sends one as soon as possible after all higher priority requisitions for the same component have been filled. (The priority may be determined by the age of the requisition or by the urgency of the base's need, as selected by the user.) Once the reparable component arrives at the CIRF or depot, it is repaired (or perhaps NRTSed again from the CIRF to the depot) and returned to that facility's own stock so that it can be issued to satisfy the next demand.

LATERAL SUPPORT

Lateral supply (between bases in the same theater) is a policy option that can be analyzed. If one base has an aircraft NFMC for some component while another base in the same theater has a serviceable spare, a lateral supply action would ship the extra component to the base with the NFMC aircraft, increasing the number of aircraft available within the theater.

Lateral repair can be emulated (as with Version 4) by placing the base's repair facilities at a dummy CIRF collocated with the base. The CIRF has instantaneous transportation to and from the collocated base, while the other bases it supports with lateral repair have a transportation delay equal to the real delay between the bases. Parts from all bases, including the collocated base, compete for the CIRF's repair resources on an equal basis.

III. CAPABILITIES, EXTENSIONS, AND LIMITATIONS

Version 5, like the earlier versions of Dyna-METRIC, provides capability assessments in the form of a performance report. Extensions facilitated by the use of Monte Carlo sampling have enhanced our ability to study management policies in distribution, lateral supply, and repair scheduling. Several capabilities in other important areas have been lost or reduced, particularly in regard to subcomponent indenture, spares requirements, and model efficiency.

CAPABILITIES

Given descriptions of the scenario, the aircraft, and the logistics system, Dyna-METRIC provides various measures of performance. Besides traditional component-oriented logistics statistics such as backorders, it provides such higher combat-oriented capability measures as the force's aircraft availability and daily sortie generation capability. For each base, the model reports the expected number of available aircraft at any specified time and confidence level. For example, it might report that on day 5 of a scenario, a given base could expect (on average) 16 available aircraft but only 13 available with 95 percent confidence.

The model also estimates the expected number of sorties a base can generate on any specified day. It assumes that a base never overflies the program specified in the scenario (though the base may fail to achieve its program because of a shortage of available aircraft), so the predicted sortie generation capability is always less than or equal to the scenario's flying program. Thus the model's daily sortie estimates reflect both requested sorties and available aircraft. Version 5 assumes full cannibalization.

A performance shortfall cannot generally be assigned to a single cause or solution: Poor component reliability, slow or inadequate repair capabilities, ineffective transportation, or too limited a supply of spares may combine to cause the problem; and the solution may require changes in any or all of those areas. To help understand the causes of performance shortfalls, Dyna-METRIC also reports which LRUs are most likely to cause NFMC aircraft. Reports are available detailing the pipeline segment contents for these (and other) LRUs, facilitating problem diagnosis.

EXTENSIONS

The new approach has allowed major extensions in the modeling of policies that enhance management flexibility. These extensions fall into three categories: distribution, lateral supply, and the scheduling of repair.

Distribution

The model has two distribution policies that determine where a depot or CIRF sends serviceable assets. Neither policy sends an asset to a location unless that location has an unfilled requisition, meaning the location has requested an asset but no asset has been shipped in response to the request. The first come, first served (FCFS) policy fills the oldest requisition. The priority distribution policy sends the asset to the location that has the greatest portion of its aircraft NFMC for that part (to the location with the greatest value of

(pipeline − stock)/aircraft). Following the latter policy generally reduces the number of unavailable aircraft.

Other distribution policies could be implemented in a subsequent version of the model. One possibility would be to relax the requirement of shipping only to locations with unfilled requisitions. Another would be to send the asset to the location that most increases the probability of achieving the theaterwide fully mission capable (FMC) goal.

Lateral Supply

Lateral supply is a policy that sends assets from bases that do not currently need them to bases that do. Lateral supply is permitted only between bases in the same theater when the following conditions are met.

- The lateral supply action(s) must cause an otherwise NFMC aircraft to become FMC.
- A base sending a component must have no aircraft NFMC for that component (the sender must have assets on the shelf).
- A base receiving a component will not first receive a serviceable asset from its own repair shop or from the depot.

The model allows lateral supply to occur during wartime, at all times, or not at all. Lateral supply tends to enhance performance over the long run, though there may be an initial drop in the level of FMC aircraft for a short period when lateral supply becomes available. This drop happens because, during that period, the components tied up in the lateral supply pipeline are not available to any base. Had they been available to the original base, they occasionally would have prevented a broken aircraft there.

Scheduling of Repair

The scheduling policy for repair is important when repair resources are limited because a decision to repair one component is also a decision not to repair another. The model incorporates several different scheduling policies.

First Come, First Served. The FCFS scheduling policy selects the component that has been waiting longest for repair. The components repaired may not be those for which there is the greatest need because the policy ignores stock levels.

Priority Based on Current Aircraft Availability. Repair priority is given to the component causing the largest number of NFMC aircraft. If no aircraft are NFMC, the component with the smallest amount of extra stock is repaired.

Priority Based on Future Aircraft Availability (Depot Only). Repair priority is given to the component that most increases the probability of satisfying a theaterwide FMC goal in the future. As currently implemented, this policy assumes there is no lateral supply while determining the next component to repair. If lateral supply is available, then a better allocation of repair resources may be possible. Test cases have indicated that this policy does better than the one based on current aircraft availability, even when there is lateral supply.

Contract System (Depot Only). The model's contract system is similar to the actual workloading system used by the depots.[1] A contract is made for a future quarter based on the current backorders, expected demands, and already contracted repairs. Priority for repair is given to the part with the lowest percentage of its contract completed. The number of repairs

[1]The depot workloading system is called MISTR, Management of Items Subject To Repair.

in the future quarter is limited not only by the availability of the repair resource and of broken components to repair, but also by the contract. This policy allows smooth operation of the depot shops and adequate planning time for the purchase of subcomponents for use during the repair process. The main disadvantage is a slow response to shortages. It does slightly worse than the FCFS rule because the number of repairs is artificially limited by the contract.

LIMITATIONS

Version 5 is clearly superior to earlier versions of the model in its representation of constrained repair and management adaptations. In other areas, though, the earlier versions are more complete.

Perhaps the most important limitation is that Version 5 does not represent the indentured nature of LRUs. As mentioned earlier, aircraft are composed of LRUs, which in turn are composed of SRUs, which in turn are composed of bits and pieces. Version 4 captures these three levels of indenture and tracks how an SRU shortage can hold up LRU repair and potentially affect NFMC rates. Version 5 in effect assumes adequate stock levels of SRUs, so that repair of an LRU is never delayed for a shortage of an SRU. LRUs are never awaiting parts (AWP).

SRUs were dropped in deference to other aspects of the problem for initial research purposes. When another version is developed, SRUs will be reintroduced; the potential effect of their unavailability should not be ignored.

Another area of analysis that has been omitted from Version 5 is the spares requirements computation. The analytic model can compute the spares level required to achieve a certain performance, in addition to predicting the performance based on a given level of spares. Version 5, though, cannot.

Version 5 does not have the extensive problem parts diagnosis of Version 4. Instead, it identifies the two worst components associated with each type of repair resource at each base. An optional file can be produced that contains very detailed information about backorders, expected pipeline segment contents, pipeline variances, etc. This file is suitable for use with other reporting programs, allowing users to design their own problem parts report. The format and content of this file are described in more detail in App. A.

Several less important features were also deleted, most of which can be easily reintroduced in a future version. Missing features include base- and CIRF-level condemnations, the option to NRTS a component before test, and time-scaling, which allowed arbitrarily long scenarios by internally rescaling such data items as the flying program and component demand rates.

The most obvious loss is in model efficiency. Version 5 runs more slowly than the earlier versions, making the analysis of more than a few hundred parts impractical. Monte Carlo sampling, however, remains the only tractable approach until new analytic results are developed that adequately capture the interactions of constrained repair and management adaptations.

IV. DESIGN OF THE MODEL

Dyna-METRIC Version 5 has a structure similar to earlier versions, but analytic computations of probabilities based on extensions of Palm's theorem [4, 1] have been replaced by Monte Carlo sampling. This version's architecture resulted from a desire to maintain consistency with previous versions' world views and the need for efficiency in execution.

A single run of the model consists of many trials. For each trial, the number of components in the various pipelines is determined as a function of time. Components move between pipelines according to random events and decision rules. Each trial yields a single result instead of the actual expected values and probability distributions as in earlier versions. One hundred trials lead to one hundred different predictions of NFMC aircraft. From those values a histogram is built, a surrogate for the probability distribution of NFMC aircraft, which is then used to report performance.

If multiple types of repair resources are being analyzed, the model prepares the histogram of NFMC aircraft for each resource separately, as though each resource were the only resource. The probability distribution of NFMC aircraft is then obtained from the histograms as follows. The probability that k or fewer aircraft are NFMC is set to the fraction of the trials in which k or fewer aircraft were NFMC for the first resource, multiplied by the fraction of the trials in which k or fewer aircraft were NFMC for the second resource, etc.

PEACETIME

Version 5 diverges widely from Version 4 in its representation of peacetime pipelines. Computing peacetime pipeline segment distributions in Version 4 was very simple because repair was unconstrained: The model computed expected segment contents by multiplying the nonvarying arrival rate by the mean service time, with the probability distributions of the pipelines of different LRUs being independent. If arrivals occurred according to a Poisson process, then the segment contents had a Poisson distribution. But in Version 5, repair is constrained; thus LRU pipelines are not independent. Once independence is lost, the specification of the joint probabilities describing system status is, as a practical matter, intractable.

Thus peacetime must be modeled explicitly, using Monte Carlo sampling. The problem is, for how long? The simple analytic result described a steady-state peacetime—one that had lasted forever. It would be impractical to have such a peacetime in Version 5. In the end, the decision has been left to the user. Peacetime is explicitly described in the input data set in the administrative data (TOP) record group. It starts on day 1, continues for as long as is specified, and need not be steady state. An adequately long peacetime for a particular analysis should result in stability by the start of war.

PIPELINES

For each trial, the model processes pipeline segments much the way Version 4 does, in an asynchronous fashion: Computations are carried through time for each segment in turn. Table 1 summarizes the order of that processing. First, the base administrative pipeline segments are analyzed, with demands for processing derived from flight line removals of LRUs.

Table 1

PIPELINE SEGMENT PROCESSING

Step	Segment	Input to This Segment is Output from Segment	Processing Type
1	Base admin	Flight line removals	unconstrained
2	Base repair	Base admin	constrained
3	Base-to-CIRF	Base repair × NRTS	unconstrained
4	CIRF admin	Base-to-CIRF	unconstrained
5	CIRF repair	CIRF admin	constrained
6	CIRF-to-depot	CIRF repair × NRTS	unconstrained
7	Depot admin	CIRF-to-depot	unconstrained
8	Depot repair	Depot admin	constrained
9	Depot on-order	Depot repair ∧ condemn	unconstrained
10	Depot backorders	Depot pipeline and stock	distribution
11	CIRF on-order	Depot backorders	on-order
12	CIRF backorders	CIRF pipeline and stock	distribution
13	Base on-order	CIRF backorders	on-order
14	Base NFMC	Base pipeline, stock and QPA	—

Next, base repair is analyzed, with demands for repair being LRUs that have completed administrative processing, and so on.

After a short explanation of how daily LRU removals are computed, we describe the four types of processing mentioned in the table—unconstrained, constrained, distribution, and on-order. The discussion omits the CIRF-related steps and considers the simpler base-depot case. Extensions to the CIRF case should be apparent.

Daily Removals

The first step computes the daily LRU removals, which enter the base administrative pipeline segment. For each LRU, the model computes the expected daily removals based on the flying program and the demand rates. The mean demands and the input variance-to-mean ratio (VTMR) imply a probability distribution P_k, the probability of k or fewer demands. A VTMR greater than one implies a negative binomial distribution; a VTMR of one, a Poisson distribution; and a VTMR less than one, a binomial distribution. The model then draws a random number Z from between zero and one. The actual demands for that LRU on that day are given by the smallest integer k such that $P_{k+1} > Z$.

Dyna-METRIC does not identify (maintain records for) individual components. Instead, it deals with numbers of components. This simplification causes some loss of representational power and makes necessary certain approximations, but the payoff in efficiency is enormous.

Unconstrained Pipeline Segment Processing

Most pipeline segments are unconstrained, meaning that arriving LRUs do not queue for processing; rather they start immediately. An example of such a segment is the first one that removed LRUs encounter—the base administrative pipeline segment. The model allows for two process time distributions, deterministic and exponential. A switch on the second TOP record controls which distribution is used.

Deterministic Process Times. With deterministic process times, all components entering a pipeline segment spend the same amount of time there before exiting. If the processing time is R days, then components that enter the segment on day n exit on day $n + R$.

Exponential Process Times. For each LRU entering the segment on day n, the model computes a processing time r drawn from an exponential distribution with mean R. The LRU then exits on day $n + r$. By keeping track of the total arrivals and departures through a given time, the model can determine the number of LRUs remaining in the pipeline.

Constrained Pipeline Segment Processing

The analysis of repair processes subject to queueing delays was a main reason for developing Version 5. For these constrained pipeline segments, the implicit assumption that all components enter the segment at the start of the day proved to be too optimistic. Instead, each day is broken into several parts, and the arrivals are randomly but uniformly distributed across the day. The number of parts into which the day is broken is dynamically computed by the model. The length of each part of the day is approximately equal to the average repair time of the components in the queue and of those that arrive that day.

For each piece of the day, repair begins if there is some LRU to repair and some resource available to repair it. The model determines the next LRU to be repaired based on the priority discipline in effect (discussed below). Once an LRU is selected, its repair time is determined (set to the mean in the deterministic case, drawn from an exponential distribution in the random case) and it is assigned to a server. The server is then unavailable until that LRU completes repair.

The following discusses the priority schemes and their underlying approximations. These approximations are necessary because the on-order segment computation is done after the repair segment computation.

First Come, First Served. This policy inducts the LRU that has waited the longest. A fairly straightforward manner of scheduling, the FCFS priority scheme still requires approximations. When the model decides what LRU to repair next, it knows only the day and not the time that the LRU joined the queue. There will frequently be a tie among several LRUs that all arrived on the same day, in which case the FCFS rule selects the LRU that most affects the NFMC rate. The number of NFMC aircraft for scheduling purposes is computed in the same manner as when scheduling is based on current aircraft availability.

Priority Based on Current Aircraft Availability. This policy inducts the LRU that is causing the most NFMC aircraft. For scheduling at a base, it chooses the LRU with the greatest value of (pipeline − stock)/quantity per aircraft. Determining this LRU is difficult, however, because the total pipeline contents are not known until all the steps in Table 1 have been completed. When the model processes a constrained repair segment, it knows about the contents of the administrative segment and the constrained repair segment up through the time it must make a scheduling decision. *But it has not yet performed any portion of the on-order segment computation.* It does not know how many LRUs have been requisitioned from the depot and not received, so it must approximate that portion of the pipeline. It assumes that the depot will instantly respond to all requisitions, so that any unreceived requisition must be due to the transportation delay between the depot and the base. Thus unreceived requisitions are assumed to be due to NRTS actions that have occurred in the past T days, where T is the expected depot-to-base transportation time.

There is a similar difficulty at the depot in terms of condemnations for which replacements may or may not have been received, and it is handled in a similar manner. More complex is the problem of predicting the current number of NFMC aircraft worldwide. There are two cases, depending on whether any sort of priority resupply is in effect. Priority resupply means either priority distribution or lateral supply. (In the long run, both have much the same effect in terms of compensating for initial stock imbalances.)

Consider first priority resupply. Let D_{ik} equal base k's administrative and repair pipeline, less stock, of LRU i. When divided by the quantity per aircraft (QPA), this approximates the number of aircraft NFMC at the base for the already computed pipeline segments. Let D_i be the approximate number of aircraft NFMC worldwide for LRU i. This is the sum of the D_{ik}, plus the depot pipeline less the depot stock, all divided by the QPA. The depot next inducts the LRU with the largest value of D_i.

If there is not any sort of responsive supply, then D_i is the depot pipeline less the depot stock, plus for each theater the largest value of D_{ik} for a base in that theater.[1]

Priority Based on Future Aircraft Availability (Depot Only). This policy maximizes the probability that an FMC goal for all bases will be met at the end of a specified planning horizon. The algorithm employed performs a marginal analysis that considers the effect of each potential LRU induction on the probability of meeting the FMC goal. The algorithm needs the current status of pipelines, stock, and NFMC aircraft, plus a prediction of the mean number of demands for each LRU during the planning horizon. It returns an ordered list of repairs. The LRU to be inducted is the highest LRU on the list that has not yet been inducted and is available in the queue.

The base pipeline quantity is needed by the algorithm but is not readily available when the algorithm is invoked. The administrative and repair portions are known, but not the number of unfilled requisitions placed by the base on the depot. However, the model can approximate this number because it knows the number of requisitions. The approximation is done each time the list is built by determining what the status would be if all depot stock and completed repairs were allocated at that point in the scenario so as to minimize the percent of NFMC aircraft at each base. Such an allocation would be optimistic because the model has perfect hindsight. The actual allocation of depot serviceables is discussed later.

Contract System (Depot Only). The implementation of this policy is actually quite clean, because the information used (expected demands, previous contracts, completed repairs) is available when the decision is made as to which LRU to induct next.

Each period, a contract is made for the expected number of demands plus any shortfall from earlier contracts. The contract being made may apply to a later period than the period in which it is made. During a period, the next LRU to be inducted is the one with the lowest percentage of completed contracted repairs. No more repairs are done than are specified in the contract.

---

[1]An alternative approach would have been to sum D_{ik} at all bases where $D_{ik} > 0$, and select that LRU with the greatest value. This works well if the number of NFMC aircraft for each LRU is evenly distributed across bases, but it fails to handle cases of apparent maldistribution. For instance, suppose LRU A was causing one aircraft to be NFMC at each of ten bases, while LRU B was causing ten NFMC aircraft at one base and none at any other base. The algorithm implemented would select LRU B, while the alternative approach would have a tie between LRUs A and B.

Distribution Processing

Distribution processing for the depot and CIRF applies to the depot-CIRF, depot-base, and CIRF-base links. The switches that control the type of processing are on the second TOP record. This discussion covers the depot-base case; the other cases are similar.

After the completion of step 9 in Table 1, the depot pipeline has been computed. Let λ_{0n} be the depot pipeline on day n. Let B_{0n} be the day n depot backorders (equivalently, the number of requisitions that the depot has received for which it has been unable to ship a serviceable LRU). Then B_{0n} is given by the maximum of zero and λ_{0n} less the initial depot stock level. If the number of requisitions on day n is R_n, then the number of requisitions the depot satisfied on day n is $S_n = B_{0,n-1} + R_n - B_{0n}$. This is not the only way this quantity could have been determined: Keeping track of the initial depot stock level, successful depot repairs, and receipts of replacements for condemned LRUs would have served as well.

Priority Distribution. This type of processing fills requisitions based on greatest need. For each base k on day n, the model computes λ_{kn}, the sum of the administrative and repair pipeline segments plus any requisitions that have not been sent. It then computes $B_{kn} = \lambda_{kn}$ − the initial base stock level. An available LRU is sent to that base with an unfilled requisition that has the highest B_{kn} per aircraft. This step is repeated S_n times for each day n. The depot does not consider lateral supply activity that may be taking place in the theater when it decides where to ship an LRU. If the LRU is sent to a base whose need has already been met through a lateral supply action, that base presumably sends it on to whichever base needs it most.

Fill Oldest Requisition First. Here requisitions are filled on a first come, first served basis. Frequently this rule is ambiguous because all that is known about a requisition is the day on which it was generated. In such instances, the LRU is sent to the base with the greatest number of unfilled requisitions placed on that day.

On-Order Processing

Determining the number of LRUs that have been ordered but not received is straightforward. From the earlier steps, the model knows how many LRUs the depot shipped per day. For each shipped LRU, the model gets the shipment time and determines what day the LRU arrives. Subtracting total arrivals from total requisitions yields the number of unfilled requisitions.

LATERAL SUPPLY

Lateral supply is done after all the scheduling and distribution decisions have been made. The model considers lateral supply actions for situations where one base has aircraft NFMC for components that other bases have in stock. An action will not be taken if the base needing the part will first receive one from local repair, the CIRF, or the depot. If multiple lateral supply possibilities exist, the preference is given to those that cause the aircraft having the fewest holes to become FMC, and to those that aid bases with the greatest fraction of their fleet unavailable.

The algorithm works as follows: The model selects the base that has an NFMC aircraft with the fewest holes. If multiple bases have aircraft NFMC for the same number of (fewest)

holes, it selects the base with the lowest FMC percent.[2] Lateral supply is considered for that base only if serviceable stock is available from other bases for all the holes on the particular aircraft. Stock to fill holes of different LRUs need not come from the same base. If there is a choice of bases with serviceable stock available, the model selects the base with the largest value of (stock – pipeline)/aircraft (the base with the largest ratio of spare stock to aircraft). The algorithm continues until all NFMC aircraft have been examined.

[2]For example, Base A has 10 aircraft, one NFMC for LRUs 1 and 2, one NFMC for LRU 2; Base B has 20 aircraft, two NFMC for LRU 2; Base C has 10 aircraft, 3 NFMC for LRUs 1 and 2. Both Base A and Base B have an aircraft NFMC for only one LRU. Base A is selected because it has 80 percent of its aircraft FMC, while Base B has 90 percent; Base C is not selected at this time because it needs two LRUs to get one of its planes FMC.

V. EXAMPLES AND USE

Perhaps the best way to illustrate Version 5's new features is by a series of examples. Not all model parameters are discussed here, but they are described fully in App. B, the Version 5 input specifications. Because this section examines features that are new to Version 5, the reader should be familiar with the general Dyna-METRIC model, Version 4 [3].

These examples analyze eight F-16 components that are tested on the computer/inertial (CI) test stand. The scenario includes five bases and a depot. The main operating base (MOB) and collocated operating bases (COB1, COB2, COB3) are in the same theater, while the fifth base (PACF) is in another. The depot is collocated with MOB and is two days away from the other bases. Putting the depot so close to the bases highlights the effect of the various depot scheduling policies. Only MOB and PACF fly during peacetime, which is through day 150 of the scenario.

There are six examples, each building on the previous example. The base case demonstrates the FCFS distribution policy at the depot. Repair is available only at the depot, where the scheduling policy is based on current aircraft availability. Priority distribution is demonstrated in the second example. The third uses the contract system of repair scheduling for peacetime operation, while the fourth also uses the contract system in wartime. The fifth example schedules repair during wartime according to a future aircraft availability goal. The sixth example allows lateral supply between bases in the same theater. The differences among the six runs are summarized in Table 2.

A different kind of example is handled separately in Sec. VI. It demonstrates the model's ability to portray the failure of test stand modules, making the repair stand unable to test some subset of the components. It uses a preprocessor to obtain the needed data.

BASE CASE

The base case demonstrates the FCFS distribution policy and the current aircraft availability scheduling policy at the depot. Because the Version 4 and Version 5 input data sets are so similar, only selected record groups are described here; Apps. C and D contain the full input and output data sets.

Table 2

SIX EXAMPLES

Case	Distribution Policy	Peacetime Scheduling	Wartime Scheduling	Lateral Supply
1	FCFS	Current availability	Current availability	No
2	Priority	Current availability	Current availability	No
3	Priority	Contract	Current availability	No
4	Priority	Contract	Contract	No
5	Priority	Contract	Future availability	No
6	Priority	Contract	Future availability	Yes

There is a major difference in the structure of input data sets between the two versions. Version 4 allowed only one of each group of component data, such as LRU description records. One of Version 4's five programs reorganized or partitioned that data set before running the rest of the model.[1] Version 5 has no utility program to do that partitioning and requires its component data to be organized differently. Instead of one group of each type of component data, it requires *separate groups for each type of repair resource.* All record groups for a given resource must be together, starting with the LRU description records. The structure of the Version 5 data set is similar to that of the Version 4 data set after partitioning.[2]

Figure 1 shows selected records from the base case data set. The first administrative record contains the title of the run. The last two fields on the second record indicate that there will be 100 trials and that the distribution policy for the depot is FCFS. The third record has the seeds for the various random number streams. The fourth record indicates that the war starts on day 151 and that performance should be reported for days 150 (peacetime), 153, 157, 160, 165, and 180.

A run-in period captures the effects of peacetime flying. It should be sufficiently long that there is pipeline stability by the start of war. The 150 day period used here seems to work well. In analyses where demands for repair are approximately equal to the repair capacity, a longer run-in period may be appropriate. If there is no peacetime flying, or if all of the aircraft are assumed to be fully mission capable at the start of the war, then no run-in period is required.

```
columns
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

Example 1 - Base case.
 1 1.0        1.0   Version 5.0                                     100        0
47511583853191473527752331477531552795271473679368911471852722438891742732297723
 151 150 153 157 160 165 180
  .
  .
  .
BASE
MOB                                                                     2.0    1
COB1                                                                    2.0    1
COB2                                                                    2.0    1
COB3                                                                    2.0    1
PACF                                                                    0.0    2
  .
  .
  .
TBED
DPT1                  5
```

Fig. 1—Selected input records, base case

[1]Version 5 is a much simpler model that is made up of only one program, a combination of Version 4's pipeline and report programs. Most data are not error checked or echoed. Running the model is straightforward.

[2]Regardless of the model version, during compilation sizing parameters must be set that specify how large a data set can be analyzed. Appendix E describes the sizing parameters for Version 5.

The base description (BASE) records contain a switch (columns 72–76) that if set to 2.0 or greater indicates that the queues for repair are lost at the start of the war, a useful feature for deployed units. In this case, all bases besides PACF lose their repair queues at the start of the war, day 151. The setting of this switch makes no difference here because there is no base-level repair and, hence, no base-level queues. The theater number (column 79) shows that all bases but PACF are in the same theater.

The server level (TBED) records indicate that the depot has five CI servers. The bases do not have any servers, so any components that fail leave immediately for the depot. The scheduling switch (column 5) has been left blank, so the scheduling algorithm used is the default: based on current aircraft availability.

The output from the run has four or five main parts, depending upon whether option 15 has been selected. For purposes of illustration, this option has been invoked in the base case only. The first part of the output (Fig. 2) is a simple echo of the input parameters. "DRIVE" scheduling refers to depot scheduling based on future aircraft availability.

```
Dyna-METRIC Version 5, the Simulation.  (October, 1987)
Example 1 - Base case.

  100 trials requested.
Default mesh-size to be used.

CIRF distribution:   First Come, First Served
Depot distribution:  First Come, First Served

First day of war:  151
Unscaled times of analysis:  150  153  157  160  165  180

If DRIVE scheduling is selected, the following parameters will be used:
         - planning horizon of  1 days
         - computation done every  1 days
         - knowledge of future scenario assumed


Base MOB  is in theater   1
Base COB1 is in theater   1
Base COB2 is in theater   1
Base COB3 is in theater   1
Base PACF is in theater   2

If DRIVE scheduling is selected, goal will be at most   0 percent E(NFMC).

Base MOB  loses repair queue upon deployment.
Base COB1 loses repair queue upon deployment.
Base COB2 loses repair queue upon deployment.
Base COB3 loses repair queue upon deployment.
```

Fig. 2—Echo of input parameters

The second part of the output provides an individual report for each resource and base, reflecting the base's performance for the set of components assigned to the resource, and assuming full cannibalization. Figure 3 shows the report for the CI resource at MOB. Because our example has only one resource, this report considers all eight components.

The first column gives the day of analysis. The second shows the expected number of aircraft broken because of components assigned to resource CI (again, assuming full cannibalization). The third column gives the variance of the number of broken aircraft. The fourth column indicates which component most frequently caused the most NFMC aircraft, and how frequently that happened. In this case, on day 150 14FB0 is the worst LRU with 4 percent probability. This probability is lower than one might expect because in some trials there were no aircraft NFMC and thus no problem parts. The last column names the next worst component and how often it caused the most aircraft to be NFMC.

The third part of the report (Fig. 4) indicates the probability of having no NFMC aircraft at any base. The target of 0 percent comes from the option selection record for the performance report (option 11).

The fourth part of output has a table for each day of analysis indicating the performance on that day. Figure 5 shows the table for day 180. The report is very similar in form to that generated by Version 4. From left to right, the columns in the report give the:

Base MOB - Resource CI

Day	Expected NFMC	NFMC Variance	Worst LRU & Prob	2nd Worst & Prob
150	0.1500	0.7875	14FB0	
			0.040	
153	1.8900	8.2579	14FB0	14AA0
			0.235	0.110
157	8.5900	31.2619	14FB0	14AA0
			0.620	0.230
160	9.1300	31.0531	14FB0	14AA0
			0.660	0.170
165	8.5400	30.5484	14FB0	14AA0
			0.605	0.170
180	6.6400	32.5904	14FB0	14AA0
			0.425	0.235

Fig. 3—Results for resource CI at base MOB

Day	Probability of achieving 0% NFMC goal
150	0.84
153	0.09
157	0.00
160	0.00
165	0.00
180	0.02

Fig. 4—Probability of achieving NFMC goal

- Name of the base.
- Number of allowable NFMC aircraft.
- Total aircraft.
- Probability of having no more than the target number of aircraft NFMC.
- Probability of achieving the requested sorties.
- Number of aircraft available with at least the specified confidence (95 percent in these examples).
- Expected number of NFMC aircraft.
- Variance of NFMC aircraft.
- Expected fraction of aircraft that are NFMC.
- Expected number of sorties achieved.
- Expected number of sorties flown by each flyable aircraft on that day.

Option 15 generates the fifth part of output—the detailed pipeline and backorder information that is written to a separate file. Figure 6 shows the portion that deals with the first LRU, 74DD0, at PACF and the depot, at the end of day 153. The total pipeline (TP) of this LRU at PACF is 0.35; at the depot, 0.93. PACF's total pipeline is due to higher echelon backorders (HEBO) of 0.34, plus an additional 0.01 LRUs in the order-and-ship pipeline (OST). These two segments differ in that HEBO represents requisitions for which no shipment has been made, while OST represents LRUs in transit that simply have not arrived at PACF. The depot pipeline has two nonzero segments, the retrograde segment (RTRO) containing an expected 0.37 LRUs, and the queue when repair is available (QRA) of 0.56 LRUs. Appendix A contains a summary of the formats and codes used.

CASE 2: PRIORITY DISTRIBUTION

The second example is the same as the base case, except with priority distribution for the depot. The modification to the input data set is simple. The last field on the second record is changed from 0 (FCFS distribution) to 1 (priority distribution), as shown in Fig. 7. Results from this case and the four remaining cases are summarized at the end of this section.

Performance based on stock on hand on day 180.

			-------------------Full cannibalization------------------							
Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
MOB	0	72	0.200	0.200	56	6.640	32.590	0.092	65.36	1.000
COB1	0	24	0.470	0.470	17	1.840	6.614	0.077	22.16	1.000
COB2	0	24	0.500	0.500	16	1.910	8.762	0.080	22.09	1.000
COB3	0	24	0.420	0.420	16	2.070	8.305	0.086	21.93	1.000
PACF	0	72	0.100	0.100	54	7.640	33.250	0.106	64.36	1.000
Total		216				20.100		0.093	195.90	

Fig. 5—Performance report

ADM	1	PACF	0	5	74DDO	1	153	0.00
QRA	2	PACF	0	5	74DDO	1	153	0.00
QRNA	3	PACF	0	5	74DDO	1	153	0.00
IW	4	PACF	0	5	74DDO	1	153	0.00
OST	6	PACF	0	5	74DDO	1	153	0.01
HEBO	7	PACF	0	5	74DDO	1	153	0.34
TP	8	PACF	0	5	74DDO	1	153	0.35
BPV	11	PACF	0	5	74DDO	1	153	1.23
EBO	9	PACF	0	5	74DDO	1	153	0.00
RTRO	0	DPT1	2	1	74DDO	1	153	0.37
ADM	1	DPT1	2	1	74DDO	1	153	0.00
QRA	2	DPT1	2	1	74DDO	1	153	0.56
QRNA	3	DPT1	2	1	74DDO	1	153	0.00
IW	4	DPT1	2	1	74DDO	1	153	0.00
OST	6	DPT1	2	1	74DDO	1	153	0.00
TP	8	DPT1	2	1	74DDO	1	153	0.93
EBO	9	DPT1	2	1	74DDO	1	153	0.93
PVAR	10	DPT1	2	1	74DDO	1	153	3.91

Fig. 6—Detailed pipeline and backorders report

```
columns
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

Example 2 - Base case, with priority distribution.
 1 1.0      1.0   Version 5.0                                  100         1
```

Fig. 7—First two records, Case 2

CASE 3: CONTRACT SYSTEM FOR PEACETIME

The third example is the same as the second, except that the depot schedules repairs during peacetime using the contract system. To do this, option 24 must be selected (Fig. 8). The first option 24 parameter indicates the length of contract periods (i.e., 30 days), and the second parameter indicates the number of periods in advance that scheduling is to be done (i.e., 2 periods). Note that although the second parameter is a real variable, it should only be set to round numbers. Here, on day 1 a contract is prepared for days 61–90. For the first two periods, the contract defaults to expected depot demands.

```
columns
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

OPT
     11  0  .95
     24 30  2.0
```

Fig. 8—Option selection records, Case 3

CASE 4: CONTRACT SYSTEM FOR ENTIRE SCENARIO

In Case 3, the depot used the contract system during peacetime. Extending the contract system to wartime is specified on the TBED (server level) record for the depot (Fig. 9). The fifth column indicates that scheduling rule 3, the contract system, is to be used. Note that the contract system may be selected only for a depot, and only if option 24 has been selected.

CASE 5: FUTURE AIRCRAFT AVAILABILITY GOAL—WARTIME

This scheduling policy builds a list of repairs designed to maximize the probability of achieving an aircraft availability goal (already specified with option 11) at some future time. The depot description record in Fig. 10 introduces two new fields. The repair schedule frequency (column 80) indicates how often the list of repairs is to be built (in this case, every day). The planning horizon (column 78) indicates when the availability goal is to be achieved (here, five days after the list is prepared). The only other change is on the TBED record, where the scheduling switch is set to 2 (not shown here).

CASE 6: LATERAL SUPPLY

Option 25 enables lateral supply (Fig. 11) between bases in the same theater. Its first parameter indicates how many days it takes a base to receive a component from another base (2 days here). The second parameter indicates when lateral supply becomes available (in this case, at the start of the war).

```
columns
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

TBED
DPT13               5
```

Fig. 9—Server level records, Case 4

```
columns
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

DEPT
DPT1                                                                         5 1
```

Fig. 10—Depot description records, Case 5

```
columns
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

OPT
    11  0  .95
    24 30  2.0
    25  2 151.
```

Fig. 11—Option selection records, Case 6

RESULTS OF ALL SIX CASES

Figure 12 shows the probabilities of achieving the 0 percent NFMC goal at all bases (from the third part of the output for all six cases); it also extracts the expected number of NFMC aircraft for each time of analysis from the performance reports.

The results are fairly intuitive. The performance in the second case is much better than in the base case, illustrating the effectiveness of priority distribution at the depot (rather than FCFS). The peacetime scheduling policy used in the third case does not have an aircraft availability orientation. As a result, performance is worse at the start of the war and never fully recovers. The differences in various wartime scheduling policies are evident in the third, fourth, and fifth cases. Not surprisingly, the contract system (Case 4) is the worst, with scheduling based on current aircraft availability (Case 3) nearly as good as scheduling based on future availability (Case 5). The sixth case shows the benefits of lateral supply during wartime.

Why aren't the peacetime performances of Cases 3, 4, and 5 the same? The random numbers used by the model on each trial differ among the three cases because of the different wartime scheduling policies, thus changing the sample means (which all reflect the same real mean). If 1,000 trials had been used instead of 100, the differences would have been smaller.

Case	Day 150	153	157	160	165	180
Probability of Achieving NFMC Goal						
1: base case	0.84	0.09	0.00	0.00	0.00	0.02
2: priority distribution	0.86	0.31	0.11	0.28	0.48	0.64
3: contract (peacetime)	0.09	0.10	0.00	0.02	0.14	0.32
4: contract (wartime)	0.13	0.02	0.00	0.00	0.02	0.06
5: future availability (war)	0.15	0.12	0.03	0.08	0.16	0.39
6: lateral supply	0.15	0.12	0.03	0.16	0.22	0.49
Expected Theater NFMC Aircraft						
1: base case	0.71	6.70	23.13	23.53	23.19	20.10
2: priority distribution	0.51	3.86	9.37	6.41	3.03	1.35
3: contract (peacetime)	14.72	14.91	25.02	19.21	14.27	5.77
4: contract (wartime)	13.17	21.73	33.18	29.69	26.62	20.57
5: future availability (war)	12.68	11.75	19.54	13.88	8.92	4.11
6: lateral supply	12.68	10.92	15.93	8.51	5.53	2.89

Fig. 12—Comparison of results from six cases

VI. REPAIR RESOURCE FAILURES

Thus far, we have assumed the repair resources, although limited, are completely reliable which of course is not the case. This section describes how the model portrays their unreliability. For repair resources such as avionics test equipment, we developed a preprocessor that takes a description of the unreliability of the test equipment and computes the special parameters needed by Dyna-METRIC for its analysis. The major portion of this section is devoted to describing this preprocessor: its mathematical underpinnings, its inputs and its outputs.

UNRELIABILITY OF REPAIR RESOURCES

An unreliable repair resource affects production in two ways. First, it is unable to repair any of its assigned LRUs while undergoing problem diagnosis. Second, the resource cannot repair its assigned LRUs until it is fixed. For elaborate types of repair resources, problem diagnosis may be a very time-consuming process. These two sources of unavailability are captured by the model in different ways.

Consider the time required for problem diagnosis, during which period the repair resource is unable to repair any of its assigned LRUs. The model needs the fraction of all operating time (time spent in self-diagnosis and time spent in LRU repair) that is due to self-diagnosis. Strictly speaking, the model requires the fraction spent in LRU repair, which implies the fraction spent in self-diagnosis. This is used as a constant in the following manner: If the self-diagnosis fraction is f, and the repair time for an LRU is r operating days, then repairing that LRU requires on average $r/(1 - f)$ days. This is not a bad representation if problem diagnosis occurs frequently and is of short duration. Less frequent but longer occurrences might be better represented as actual failures that affect all LRUs, described next.

The other source of repair unavailability is when the repair resource is broken. The broken resource can be either PMC or NMC. A PMC resource can repair some but not all of its assigned LRUs; an NMC resource can repair none of its LRUs.

Dyna-METRIC treats resource failures in a simplistic way. Although one could view repair resources as being somewhat akin to aircraft, in that they are composed of several modules that may fail and for which serviceable spares may exist, all that we explicitly model are aggregate module backorders. A backorder occurs when a module fails and no spare module is immediately available. Input to the model is b, the backorder rate per operating day. Backorders occur randomly according to a Poisson process with mean b. The backorder persists for a random length of time whose mean is supplied in the model's input and whose probability distribution is exponential (though if module resupply is cut off, the backorder will persist even longer). We assume that two backorders of the same type never occur at the same time at the same location (in avionics shops, at least, it very seldom happens), so that all backorders can be consolidated onto a single server of the repair resource.

Associated with each LRU is the probability that a backorder renders the repair resource incapable of repairing the LRU. When a backorder occurs, the model uses those probabilities to randomly determine which LRUs are affected.

This is by no means a perfect representation of the process. In developing Version 5, we experimented with explicit representation of modules. Dyna-SCORE [8], a simulation of a

single level of constrained repair, is even more explicit in its representation. Through experimentation, we have satisfied ourselves that the current method does fairly well, though not reflecting all the nuances, and have chosen it because of its more efficient use of computer resources (it runs faster and requires less data).

A problem remains with the unavailability of data. Standard systems currently collect data about neither backorder rates nor the probability that a random backorder affects a given LRU. Thus we built a preprocessor that uses more collectable data to compute the inputs needed by Dyna-METRIC.

The preprocessor requires module-related data, including the number of each module per server for each repair resource, module spares level, mean module lifetime, module resupply time, and the number of each module that must be operational to test a given LRU. It then computes output data for each type of repair resource, including the fraction of time spent in self-diagnosis, the backorder rate, and the mean backorder duration; for each LRU it computes the probability that a random backorder affects that LRU.

MATHEMATICS OF THE PREPROCESSOR

In this discussion, we assume that modules are assigned to unique repair resources, that the quantity per server is one, and that there is only one server of each type. In the preprocessor itself, modules may be assigned to more than one type of repair resource, modules may have quantities per server greater than one, and there may be more than one server of each type. The extension of the mathematics to the full case is straightforward and is not made here to keep the general concepts clear.

Notation

J - Number of modules on a repair resource.
d_j - Break rate per operating day of module j.
S_j - Stock level of module j.
R_j - Average resupply time of module j.
b_j - Backorder rate of module j.
$E_j(B)$ - Expected number of backorders for module j.
b - Backorder rate for the server; the sum of b_j.
$E(B)$ - Expected number of backorders for the server, or the sum of $E_j(B)$.

We first compute b_j, the backorder rate for module j. Assuming that the repair resources operate continuously, Palm's theorem tells us that the expected number of failed modules in the system is Poisson with mean $\lambda = d_j R_j$, so that the probability of k failed modules, or p_{jk}, is $p_{jk} = e^{-\lambda}\lambda^k/k!$. The expected number of backorders is

$$E_j(B) = \sum_{k=S_j}^{\infty} p_{jk}(k - S_j) = \lambda - S_j \quad \sum_{k=0}^{S_j - 1} p_{jk}(k - S_j) \ .$$

The probability that there is no stock on hand is the probability that the number of failed modules is greater than or equal to S_J. Let P_{j0} be the probability that there is no stock on hand for module j. That is,

$$P_{j0} = 1 - \sum_{k=0}^{S_j - 1} p_{jk} \ .$$

A backorder occurs when there is a module failure and no stock on hand, so $b_j = d_j P_{j0}$. The backorder rate needed by Dyna-METRIC is

$$b = \sum_{j=1}^{J} b_j \ .$$

Dyna-METRIC also needs ER, the effective backorder resupply time, which takes into account the possibility of initial stock and may differ from R_j. Suppose there was initially stock on hand. By the time a backorder occurs, multiple orders will already have been placed, so that a new module arrives sooner than R_j. Computing ER is not difficult. We know from Little's formula [9] that $E(B) = b \times ER$. So $ER = E(B)/b$.

Another quantity needed by Dyna-METRIC is q_i, the probability that a random backorder renders the server incapable of testing LRU i. Let F_i be the set of modules that must be operational in order to test LRU i. Then

$$q_i = \sum_{j \in F_i} b_j / b \ .$$

The final result computed by the preprocessor and used by Dyna-METRIC is the availability rate, α. This is the fraction of the operating time that is spent in the test of LRUs, rather than in self-test or problem diagnosis. α is given by

$$\alpha = \frac{1/b}{1/b + \text{Expected diagnostic time}} \ ,$$

where the expected diagnostic time was a preprocessor input.

EXAMPLE USING THE PREPROCESSOR

This example demonstrates not only the effects of including unreliability in one of the Dyna-METRIC cases from the previous section, but also shows the use of the preprocessor to prepare the data Dyna-METRIC needs to represent unreliability. The reader should refer to App. F for detailed input specifications, and to Apps. G and H for the complete sample input and output excerpted below.

Preprocessor Inputs

There are three parts to the preprocessor input: repair resource definitions, module definitions, and a module essentiality matrix. The needed data are similar to those used by Dyna-SCORE.

Repair Resource Definitions. These repair resource definitions (Fig. 13) are based on the four resources in an F-16 avionics shop. The previous examples in Sec. V analyzed only the CI repair resource, which shares modules with the PP, DI, and RF repair resources. Demands generated by those resources must also be reflected. The preprocessor must be run for each location with repair resources. In our cases, this has been only the depot. These records indicate that at the depot there are two each of the PP, DI, and RF servers, and five of the CI.

```
columns
           1         2
123456789012345678901

PP         2  0.3842  0
DI         2  0.4755  0
RF         2  0.5830  0
CI         5  0.5431  8
```

Fig. 13—Repair resource definitions

The amount of repair time lost for each module failure (columns 12–17) has two parts. One is the diagnostic time needed to identify the problem. The other has to do with how Dyna-METRIC treats LRUs that are in test when the server fails: It credits them for time spent on the server so that when the server again becomes available, they do not spend a full repair time completing repair. If this representation is inappropriate to the situation being analyzed (and it frequently is), then the expected accrued repair time should be added in. In most cases, the expected accrued repair time is the expected LRU repair time, weighted by LRU demand rates.

The number of LRUs repaired by each repair resource (column 21) enables the preprocessor to compute the probability that a PMC server can still test a given LRU. Zeroes have been entered on the records for the PP, DI, and RF servers because we have no interest in the LRUs they test; we only care about the eight LRUs tested by the CI servers.

Module Definitions. Figure 14 gives the header record for the module definitions and the first four records from that section. From left to right, the fields contain the module name, the module's mean time between failures (MTBF) in operating days, module stock level, and expected module resupply time in days; then for each repair resource, the quantity of the module that appears on the resource. Here, the first three modules appear on each type of resource, the fourth module appears only on the RF and CI servers.

Module Essentiality Matrix. Figure 15 shows the header record for the module essentiality matrix with records for the first four modules. Records must be in the *same order as the module definition records* because module names are not checked to ensure matches. The

```
columns
         1         2         3         4         5         6
1234567890123456789012345678901234567890123456789012345678901

MOD                     MTBF  STK  RESUPPLY   PP    DI    RF    CI
A_AAA                 7560.5    1    14.0      1     1     1     1
A_AAD                 3780.3    0    14.0      1     1     1     1
A_AAE/ADB             6520.3    0    14.0      2     2     2     1
ACAFO/ADAFO            889.4    1    14.0      0     0     1     1
```

Fig. 14—Module definitions

```
columns
           1         2
1234567890123456789012345

MTRX                12345678
A_AAA               11111111
A_AAD               11111111
A_AAE/ADB           11111111
ACAFO/ADAFO         00100000
```

Fig. 15--Module essentiality matrix

matrix shows how many of each module must be working to test each LRU. Here, the first three modules must be working for any LRU to be repaired. If the fourth module has failed, only the third LRU is affected; the other LRUs can still be tested.

Preprocessor Outputs

The preprocessor builds a single output file comprising various reports. The first three reports echo the input data. The last three, for each repair resource, provide overall results, module backorder rates and resupply times, and the probabilities that a PMC server can test each type of LRU.

Echo of Input Data. Figure 16 shows excerpts of the three reports that echo the input data, which define the repair resources, the modules, and the LRUs to which the modules apply.

Overall Repair Resource Report. The overall results for the CI resource (Fig. 17) provide information needed by Dyna-METRIC. The backorder rate (0.0115) and resupply time (12.0 days) go on the server level (TBED) records. The server availability on the TEST record must be adjusted to 0.914 of the previous value we used, 0.790 (which reflected such things as down time between shifts of operators), so the new server availability is 0.722.

Other information produced here is not used by Dyna-METRIC. The module failure rate, which is much greater than the module backorder rate, points to an adequate stockage position. In fact, the rate of failures for which there is stock is 0.172 per operating day, with a mean time between events of 5.80 days.

Module Backorder Rate and Resupply Time Report. None of the information provided by this report (excerpted in Fig. 18) is used by Dyna-METRIC. Briefly, it converts input about module failures, stock, and resupply time to information about module backorders. For example, recall that the fourth module's MTBF was 889.4 operating days, stock level was one, and resupply time was 14 days (Fig. 14). Its mean time between backorders (MTBB) is an order of magnitude greater: 8524.6 days, or 0.0001173 per operating day. The expected duration of the backorder condition is just seven days.

Probability a PMC Server Can Test an LRU. Of great importance in modeling unreliable repair resources with Dyna-METRIC is the probability that a PMC server can still test a given LRU. Figure 19 is the preprocessor report for resource CI that provides those values. Some LRUs have a high probability of being testable, even if the server has a single

```
Dyna-METRIC Version 5 Backorder Rate and Effective Resupply Time Program

Stand Number Ex(Diagnosis Time)
 PP       2            0.3842
 DI       2            0.4755
 RF       2            0.5830
 CI       5            0.5431

Input data:
     Module name          MTBF      stock    resupply  PP    DI    RF    CI
     A_AAA               7560.500     1       14.000     1     1     1     1
     A_AAD               3780.300     0       14.000     1     1     1     1
     A_AAE/ADB           6520.300     0       14.000     2     2     2     1
     ACAFO/ADAFO          839.400     1       14.000     0     0     1     1
           .
           .
           .

     Module essentiality matrix:

     A_AAA              11111111
     A_AAD              11111111
     A_AAE/ADB          11111111
     ACAFO/ADAFO        00100000
           .
           .
           .
```

Fig. 16—Echo of preprocessor input

```
Results for stand CI   :
     Backorder rate               :     0.01148698
     Resupply time                :    12.00329690
     Server availability (alpha):       0.91438824
     Failure rate                 :     0.18388136
     Failure less backorder rate:       0.17239438
     Mean time between failures that are not
       backorders                 :     5.80065298
```

Fig. 17—Overall repair resource report

Module name	MTBB	b.o. rate	resupply
A_AAA	100000.000	0.0000100	7.022
A_AAD	3780.300	0.0002645	14.000
A_AAE/ADB	6520.300	0.0001534	14.000
ACAFO/ADAFO	8524.624	0.0001173	7.129

Fig. 18—Module backorder rate and resupply report

```
Stand CI   LRU conditional probabilities:

LRU  1 = 0.7527
LRU  2 = 0.3737
LRU  3 = 0.6688
LRU  4 = 0.4699
LRU  5 = 0.4189
LRU  6 = 0.3843
LRU  7 = 0.7619
LRU  8 = 0.7619
```

Fig. 19—Probability a PMC server can test an LRU

backorder. For instance, LRU 1 has a three out of four chance. Others, especially LRU 6, need more of the modules in order to be tested, so have a lower probability. These conditional probabilities go on the VTM records in the Dyna-METRIC data set.

Use in Dyna-METRIC

The information output by the preprocessor is used by Dyna-METRIC in the TEST, TBED and VTM record groups. To illustrate the use of these data, we modify our previous Case 5, which utilizes contract repair during peacetime and schedules repair based on future aircraft availability during wartime. Lateral supply is not available.

Figure 20 shows placement of the new data. The probabilities that a PMC server can repair a given LRU appear on the VTM records. The server availability just computed (0.722) goes on the TEST record. The resource's backorder rate (0.0115) and resupply time (12.0 days) go on the TBED records.

As expected, predicted performance is degraded when one explicitly considers the effects of unreliable repair resources. Figure 21 compares the new results with those of Case 5 (reliable resources).

```
columns
         1         2         3         4
1234567890123456789012345678901234567890

VTM
74DDO               1.0  1.0  4.0 .753
74DAO               1.0  1.0  4.0 .374
74CAO               1.0  1.0  4.0 .669
14FBO               1.0  1.0  4.0 .470
14ADO               1.0  1.0  4.0 .419
14AAO               1.0  1.0  4.0 .384
14AGO               1.0  1.0  4.0 .762
14AFO               1.0  1.0  4.0 .762
  .
  .
  .
TEST
CI              .722
TBED
DPT12.011512 0 0. 0.  5
```

Fig. 20—TEST, TBED, and VTM records, unreliability case

	Day 150	Day 153	Day 157	Day 160	Day 165	Day 180
Reliable resources (case 5)	12.68	11.75	19.54	13.88	8.92	4.11
Unreliable resources	14.98	12.44	19.97	14.12	11.38	7.90

Fig. 21—Expected NFMC aircraft: reliable vs. unreliable resources

Appendix A

PIPELINE FILE FORMATS

Pipeline contents are summarized when option 15 is selected. A record is written to a separate file for each time of analysis, for each pipeline segment, for each LRU, and for each location. In addition to the usual pipeline segments, there is also a record for the total pipeline variance for each LRU, for each location.

Columns	Format	Description
1-7	aaaa ii	Pipeline segment code & number. RTRO 0 - Retrograde (to the location) ADM 1 - Administrative pipeline segment QRA 2 - Queue, repair available QRNA 3 - Queue, repair not available IW 4 - In work OST 6 - In the forward pipeline segment HEBO 7 - Ordered, but not yet shipped (OST + HEBO appears in Version 4 as ordered but not received) TP 8 - Total pipeline EBO 9 - Backorders (not divided by QPA) PVAR 10 - Sample variance of the depot pipeline BPV 11 - Sample variance of the base pipeline
10-13	aaaa	Name of location to which record applies.
15	i	Echelon. 0 - Base 1 - CIRF 2 - Depot
17-18	ii	Location number. This is in relation to other locations of the same echelon. If there are two bases and a depot, a location number of 1 might be base 1 or depot 1 (column 15 determines which).
20-35	a16	LRU name.
38-40	iii	LRU number.
42-45	iiii	Time of analysis.
47-56	f10.2	Size of pipeline segment.

Appendix B

INPUT SPECIFICATIONS

General notes:

- All fields must be nonnegative unless otherwise specified.
- A blank is the same as a zero.
- Times are specified as days, but any consistent unit is acceptable.
- Only records groups associated with component data may appear more than once in an input data set (once per repair resource).

Order and Structure of Input Data Sets

	Record Group
Administrative Data:	
Four records that specify the run's heading, administrative delays for the three echelons, random number seeds, and times of analysis	TOP
Option selections	OPT
Location Descriptions:	
Depot descriptions (optional)	DEPT
CIRF descriptions (optional)	CIRF
Base descriptions	BASE
Depot transportation (optional)	TRNS
Scenario Data:	
Aircraft levels	ACFT
Sortie rates	SRTS
Maximum sortie rates	TURN
Attrition rates (optional)	ATTR
Flying hours per sortie (optional)	FLHR
Component Data (one set per repair resource):	
LRU descriptions	LRU
Application fractions (optional)	APPL
Variance to mean data (optional)	VTM
Repair resource data:	
Repair resource availability	TEST
Server levels	TBED
LRU repair assignments	TPRT
Stock levels (optional)	STK

USING IMPLIED DECIMAL POINTS

Three classes of data are used in Dyna-METRIC: alphanumeric (a), integer (i), and real (x). The fields associated with real data use an implied decimal point, which may be overridden with an explicit decimal point.

To use the implied decimal point, we need to know where the point is located. Throughout this appendix, "X" denotes a digit to the left of the decimal point and "x" denotes a digit to the right. For example, a format representation of "XXXxx" for columns 5-9 means there is an implied point between columns 7 and 8.

An easier method is to include a decimal point explicitly in the data. The data need fit only within the columns to which they are assigned and need not be right-justified. This method has the advantage of allowing a greater range of entries but the disadvantage of using one of the columns in the field to contain the decimal point, thus reducing by one the available significant digits that can be used.

Whichever method the user chooses depends on the values to be coded. Suppose ten and a half is to be coded in the field defined "XXXxx". We could use either method, entering " 1050" to use the implied point or overriding it with "10.5 " or " 10.5". In this example the range of entries is .01 to 999.99 for the implied point with up to five significant digits, and .0001 to 9999. for the explicit decimal point with up to four significant digits.

Below are examples illustrating how various values can be coded.

Format	Value to be Coded	Explicit Decimal Point	Implied Decimal Point
XXxxxx	2.5	"2.5 "	" 25000"
	999.03	"999.03"	--
	99.0359	--	"990359"
XXX	2.8	"2.8"	--
	725.	--	"725"
	23.	"23."	" 23"

Aircraft Levels

Header record: ACFT

Restriction: Follow the BASE record group.

General description:
These records specify how many aircraft are assigned to each base on each day of the scenario. Bases for which ACFT records are not given will be assigned no aircraft.

```
Columns
         1         2         3         4
12345678901234567890123456789012345678901234567890123456

aaaaXXXXiiiiXXXXiiiiXXXXiiiiXXXXiiiiXXXXiiiiXXXX
|   |   |   |   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   |   |   Sixth aircraft level
|   |   |   |   |   |   |   |   |   |   Day sixth level starts
|   |   |   |   |   |   |   |   |   Fifth aircraft level
|   |   |   |   |   |   |   |   Day fifth level starts
|   |   |   |   |   |   |   Fourth aircraft level
|   |   |   |   |   |   Day fourth level starts
|   |   |   |   |   Third aircraft level
|   |   |   |   Day third level starts
|   |   |   Second aircraft level
|   |   Day second level starts
|   First aircraft level
Base name
```

Detailed description:
The maximum number of aircraft levels is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than six levels follow the format of the previous fields. Each day a level starts must be greater than the previous day.

For example, a record containing

```
BAS1   0 151  18 158   9
```

indicates that base BAS1 initially has no aircraft. Starting on day 151, BAS1 has 18 aircraft. On day 158, the level reduces to nine aircraft that lasts throughout the scenario.

Columns	Format	
1-4	aaaa	Base name. The name of the base for which aircraft levels are specified. Must be named in the BASE record group. Enter at most one record per base.
5-8	XXXX	First aircraft level.
9-12	iiii	Day second level starts.
13-16	XXXX	Second aircraft level.
17-20	iiii	Day third level starts.
21-24	XXXX	Third aircraft level.
25-28	iiii	Day fourth level starts.
29-32	XXXX	Fourth aircraft level.
33-36	iiii	Day fifth level starts.
37-40	XXXX	Fifth aircraft level.
41-44	iiii	Day sixth level starts.
45-48	XXXX	Sixth aircraft level.

Application Fractions

Header record: APPL

Restriction: Appear at most once per repair resource, following the LRU records associated with that resource.

General description:
These records specify the fraction of each base's aircraft that contain a given LRU. Bases for which application fractions are not specified default to application fractions of one (all aircraft at the base contain the LRU).

```
Columns
          1         2         3         4
12345678901234567890123456789012345678901234567

aaaaaaaaaaaaaaaa aaaaXXXxx aaaaXXXxx aaaaXXXxx
|                |   |     |   |     |   |
|                |   |     |   |     |   Third application fraction
|                |   |     |   |     Third base name
|                |   |     |   Second application fraction
|                |   |     Second base name
|                |   First application fraction
|                First base name
LRU name

           4     5         6         7
           890123456789012345678901234567

           aaaaXXXxx aaaaXXXxx aaaaXXXxx
           |   |     |   |     |   |
           |   |     |   |     |   Sixth application fraction
           |   |     |   |     Sixth base name
           |   |     |   Fifth application fraction
           |   |     Fifth base name
           |   Fourth application fraction
           Fourth base name
```

Detailed description:
Each application fraction must be between zero and one. Application fractions for up to six bases may be entered on a single record. If more are needed, multiple records are allowed.

For example, records containing

```
WIDGET          BAS1  .50 BAS2  .50 BAS3  .50 BAS4  .50
WIDGET          BAS5 1.00 BAS6 1.00
```

indicate that LRU WIDGET appears on half the aircraft at the first four bases and on all the aircraft at the last two bases. (Note that the data could have been entered on one record.)

Columns	Format	
1-16	a16	LRU name. The name of the LRU for which application fraction data are specified. Must be named in the LRU record group. Enter as many records as needed per LRU.
18-21	aaaa	First base name. Name of the base to which first application fraction applies.
22-26	XXXxx	First application fraction. Fraction of the aircraft stationed at first base that contain the LRU.
28-31	aaaa	Second base name.
32-36	XXXxx	Second application fraction.
38-41	aaaa	Third base name.
42-46	XXXxx	Third application fraction.
48-51	aaaa	Fourth base name.
52-56	XXXxx	Fourth application fraction.
58-61	aaaa	Fifth base name.
62-66	XXXxx	Fifth application fraction.
68-71	aaaa	Sixth base name.
72-76	XXXxx	Sixth application fraction.

Attrition Rates

Header record: ATTR

Restriction: Follow the BASE and ACFT record groups.

General description:

These records specify the fraction of aircraft that are attrited on average per sortie at each base on each day. Aircraft at bases for which ATTR records are not given do not experience attrition.

```
Columns
         1         2         3         4         5
123456789012345678901234567890123456789012345678901234

aaaaXXxxxiiiiXXxxxiiiiXXxxxiiiiXXxxxiiiiXXxxxiiiiXXxxx
|   |    |   |    |   |    |   |    |   |    |   |
|   |    |   |    |   |    |   |    |   |    |   Sixth attrition rate
|   |    |   |    |   |    |   |    |   |    Day sixth rate starts
|   |    |   |    |   |    |   |    |   Fifth attrition rate
|   |    |   |    |   |    |   |    Day fifth rate starts
|   |    |   |    |   |    |   Fourth attrition rate
|   |    |   |    |   |    Day fourth rate starts
|   |    |   |    |   Third attrition rate
|   |    |   |    Day third rate starts
|   |    |   Second attrition rate
|   |    Day second rate starts
|   First attrition rate
Base name
```

Detailed description:

The maximum number of attrition rates is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than six rates follow the format of the previous fields. Each day a rate starts must be greater than the previous day.

For example, a record containing

```
BAS1  .01 151  .02
```

indicates that base BAS1 loses .01 aircraft per sortie (one aircraft per hundred sorties) flown on the first 150 days. On day 151 and for the rest of the scenario, BAS1 loses two aircraft per hundred sorties flown.

Columns	Format	
1-4	aaaa	Base name. The name of the base for which attrition rates are specified. Must be named in the BASE record group. Enter at most one record per base.
5-9	XXxxx	First attrition rate.
10-13	iiii	Day second rate starts.
14-18	XXxxx	Second attrition rate.
19-22	iiii	Day third rate starts.
23-27	XXxxx	Third attrition rate.
28-31	iiii	Day fourth rate starts.
32-36	XXxxx	Fourth attrition rate.
37-40	iiii	Day fifth rate starts.
41-45	XXxxx	Fifth attrition rate.
46-49	iiii	Day sixth rate starts.
50-54	XXxxx	Sixth attrition rate.

Base Descriptions

Header record: BASE

Restriction: Follow the DEPT and CIRF record groups (if any).

General description:
These records describe the availability of resupply at each base, name the base's CIRF (if any), and describe the transportation resources connecting the base and CIRF. A record is required for each base.

```
Columns
         1         2         3         4
1234567890123456789012345678901234567890

aaaaaaaaXXXxxXXXxxXXXxx XXXxxXXXxxXXXxx
|   |   |    |    |     |    |    |
|   |   |    |    |     |    |    Resupply start
|   |   |    |    |     |    CIRF cutoff duration
|   |   |    |    |     CIRF cutoff
|   |   |    |    CIRF start
|   |   |    CIRF-to-base transportation time
|   |   Base-to-CIRF transportation time
|   CIRF name
Base name

           4        5         6         7         8
           1234567890123456789012345678901234567890

           XXXxxXXXxx                XXXxxXXXxxiiii
           |    |                    |    |    |  |
           |    |                    |    |    |  Onshore switch
           |    |                    |    |    Assigned theater
           |    |                    |    Deployment indicator
           |    |                    Sustained demand start time
           |    Resupply cutoff duration
           Resupply cutoff
```

Detailed description:
CIRF resupply and cutoff parameters also apply to the retrograde (base-to-CIRF) pipeline if the cutoff direction switch in the TOP record group is set.

Detailed description:

Columns	Format	
1-4	aaaa	Base name. The name of the base. This may be any string of four characters as long as it is neither a keyword (such as "BASE") nor the name of another base, CIRF or depot.
5-8	aaaa	CIRF name. The name of the CIRF that serves this base. Must be named in the CIRF record group. If the base is not served by a CIRF, this field must be blank.
9-13	XXXxx	Base-to-CIRF transportation time (in days).
14-18	XXXxx	CIRF-to-base transportation time (in days).
19-23	XXXxx	CIRF start. Day resupply from the CIRF first becomes available.
25-29	XXXxx	CIRF cutoff. Day resupply from the CIRF is first cut off.
30-34	XXXxx	CIRF cutoff duration. Number of days resupply from the CIRF is cut off.
35-39	XXXxx	Resupply start. Day resupply of components ordered from a supplier other than the CIRF or depot first becomes available.
41-45	XXXxx	Resupply cutoff. Day resupply of components ordered from a supplier other than the CIRF or depot is cut off.
46-50	XXXxx	Resupply cutoff duration. Number of days that resupply of components ordered from a supplier other than the CIRF or depot is cut off.
67-71	XXXxx	Sustained demand start time. Day that components begin to break according to their sustained demand rates (entered in the VTM record group) as opposed to their wartime demand rates. If set to blank or zero, the wartime rates remain in effect for the entire wartime scenario.

Columns	Format	
72-76	XXXxx	Deployment indicator. If set to 2.0 or greater, the base deploys on the first day of the war (specified on the third TOP record) and loses the contents of its repair queue upon deployment.
77-79	iii	Assigned theater. The number of the theater to which the base belongs. A value of blank, 0 or 1 means theater #1. Lateral supply is not permitted between bases assigned to different theaters.
80	i	Onshore switch. Set to 1 to indicate an onshore base; set to 0 to indicate an offshore base. (LRUs can have two different demand rates, one for each base type.)

CIRF Descriptions

Header record: CIRF

Restriction: Precede the BASE record group.

General description:
These records describe the availability of resupply at each CIRF.

```
Columns
         3         4         5         6         7
1234...01234567890123456789012345678901234567890123456

aaaa        XXXxx XXXxxXXXxx                  XXXxx
|           |     |    |                      |
|           |     |    |                      Deployment indicator
|           |     |    Resupply cutoff duration
|           |     Resupply cutoff
|           Resupply start
CIRF name
```

Detailed description:

Columns	Format	
1-4	aaaa	CIRF name. The name of the CIRF. This may be any string of four characters as long as it is neither a keyword (such as "CIRF") nor the name of another base, CIRF or depot.
35-39	XXXxx	Resupply start. Day resupply of components ordered from a supplier other than the depot first becomes available.
41-45	XXXxx	Resupply cutoff. Day resupply of components ordered from a supplier other than the depot is cut off.
46-50	XXXxx	Resupply cutoff duration. Number of days that resupply of components ordered from a supplier other than the depot is cut off.
72-76	XXXxx	Deployment indicator. If set to 2.0 or greater, the CIRF deploys on the first day of the war (specified on the third TOP record) and loses the contents of its repair queue upon deployment.

Depot Descriptions

Header record: DEPT

Restriction: Precede the BASE record group.

General description:

These records describe resupply availability and repair scheduling policy parameters for each depot. Warning: if scheduling is based on future aircraft availability (on TBED record), the values associated with the first DEPT record apply to all depots (the three repair scheduling parameters entered here are NOT depot dependent).

```
Columns
        3         4         5   7         8
12345...012345678901234567890...01234567890

aaaai        XXXxx XXXxxXXXxx          iiii
|   |        |     |    |              | |
|   |        |     |    |              | Repair schedule frequency
|   |        |     |    |              Repair schedule planning horizon
|   |        |     |    Resupply cutoff duration
|   |        |     Resupply cutoff
|   |        Resupply start
|   Repair schedule prediction
Depot name
```

Detailed description:

Columns	Format	
1-4	aaaa	Depot name. The name of the depot. This may be any string of four characters as long as it is neither a keyword (such as "DEPT") nor the name of another base, CIRF or depot.
5	i	Repair schedule prediction. How the repair schedule based on future aircraft availability views the future. Set to blank or 0 if it schedules according to a known projected flying program. Set to 1 if it assumes the flying schedule for the first day of the planning horizon is the flying schedule for all days of the planning horizon. Set to 2 if it assumes that the first day of the planning horizon is the first day of the conflict.

Columns	Format	
35-39	XXXxx	Resupply start. Day resupply of components ordered from an outside supplier first becomes available.
41-45	XXXxx	Resupply cutoff. Day resupply of components ordered from an outside supplier is cut off.
46-50	XXXxx	Resupply cutoff duration. Number of days that resupply of parts ordered from an outside supplier is cut off.
77-78	ii	Repair schedule planning horizon. The repair schedule based on future aircraft availability maximizes the probability of achieving the FMC goal this number of days into the future.
79-80	ii	Repair schedule frequency. The frequency with which the computation is done for the repair schedule based on future aircraft availability. For example, a value of 5 means it will be done on day 1, day 6, day 11, etc.

Flying Hours per Sortie

Header record: FLHR

Restriction: Follow the BASE record group.

General description:
These records specify how many flying hours are required per sortie at each base on each day. Aircraft at bases for which FLHR records are not given are assumed to fly sorties of one hour each.

```
Columns
         1         2         3         4
123456789012345678901234567890123456789012345678

aaaaXXXXiiiiXXXXiiiiXXXXiiiiXXXXiiiiXXXXiiiiXXXX
|   |   |   |   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   |   |   Sixth flying hours level
|   |   |   |   |   |   |   |   |   |   Day sixth level starts
|   |   |   |   |   |   |   |   |   Fifth flying hours level
|   |   |   |   |   |   |   |   Day fifth level starts
|   |   |   |   |   |   |   Fourth flying hours level
|   |   |   |   |   |   Day fourth level starts
|   |   |   |   |   Third flying hours level
|   |   |   |   Day third level starts
|   |   |   Second flying hours level
|   |   Day second level starts
|   First flying hours level
Base name
```

Detailed description:
The maximum number of flying hour levels is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than six levels follow the format of the previous fields. Each day a level starts must be greater than the previous day.

For example, a record containing

```
BAS1  2. 154 1.5
```

indicates that aircraft at base BAS1 fly sorties of two hours each through the day 153. From day 154 on, they fly sorties of one and a half hours each.

Columns	Format	
1-4	aaaa	Base name. The name of the base for which flying hours per sortie are specified. Must be named in the BASE record group. Enter at most one record per base.
5-8	XXXX	First flying hours level.
9-12	iiii	Day second level starts.
13-16	XXXX	Second flying hours level.
17-20	iiii	Day third level starts.
21-24	XXXX	Third flying hours level.
25-28	iiii	Day fourth level starts.
29-32	XXXX	Fourth flying hours level.
33-36	iiii	Day fifth level starts.
37-40	XXXX	Fifth flying hours level.
41-44	iiii	Day sixth level starts.
45-48	XXXX	Sixth flying hours level.

LRU Descriptions

Header record: LRU

Restriction: Appear once per repair resource, following the scenario record groups.

General description:
These records describe the failure, repair and resupply characteristics of each LRU. A pair of these records is required for each LRU.

```
Columns (first record of pair)
         1         2         3         4
1234567890123456789012345678901234567890

aaaaaaaaaaaaaaaa aaaa i iiii    XXxxxxx
|                |    | ||      |
|                |    | ||      Onshore demand rate
|                |    | ||
|                |    | |Quantity per aircraft
|                |    | CIRF reparability switch
|                |    Level of repair
|                Depot name
LRU name

        4         5         6         7         8
        1234567890123456789012345678901234567890

        XXxxxxxXXXxx XXxx XXxxXXXxx XXxx XXxx
        |      |     |    |   |     |    |
        |      |     |    |   |     |    CIRF-served base NRTS
        |      |     |    |   |     |      percentage to contractor
        |      |     |    |   |     CIRF-served base NRTS rate
        |      |     |    |   CIRF-served base repair time
        |      |     |    Lone base NRTS percentage to contractor
        |      |     Lone base NRTS rate
        |      Lone base repair time
        Offshore demand rate
```

Detailed description:
Repair time is the time the repair resource is exclusively dedicated to the LRU (excluding time spent in the queue).

```
Columns (second record of pair)
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

aaaaaaaaaaaaaaaa XXxx XXxx XXxxXXXxx      XXxxXXXXxXXXXx XXXXXXXX
|                |    |    |   |          |   |    |     |
|                |    |    |   |          |   |    |     Cost
|                |    |    |   |          |   |    Wartime resupply time
|                |    |    |   |          |   Peacetime resupply time
|                |    |    |   |          Depot condemnation rate
|                |    |    |   Depot repair time
|                |    |    CIRF NRTS percentage to contractor
|                |    CIRF NRTS rate
|                CIRF repair time
LRU name
```

First record of pair:

Columns	Format	
1-16	a16	LRU name. The name of the LRU. This may be any string of 16 characters as long as it is neither the name of another LRU nor the first four characters a keyword (such as "BASE1 ENGINE").
18-21	aaaa	Depot name. The name of the depot that repairs this LRU. Must be named in the DEPT record group. If the LRU is not repaired by a depot, this field must be blank.
23	i	Level of repair. Set to 1 if the LRU can be repaired at a base, CIRF or depot. Set to 2 if the LRU can be repaired at a CIRF or depot but not a base. Set to 3 if the LRU can only be repaired at a depot.
25	i	CIRF reparability switch. Set to 1 if a CIRF can repair the LRU; set to 0 or blank if it cannot. This field is disregarded if the level of repair is 3 (depot only).
26-28	iii	Quantity per aircraft. Number of this LRU per aircraft at all bases.

Columns	Format	
34-40	XXxxxxx	Onshore demand rate (initial). The onshore demand rate (or fraction of LRUs that break per flying hour at onshore bases) is the product of this number and the onshore demand rate multiplier from the VTM record group.
41-47	XXxxxxx	Offshore demand rate (initial). The offshore demand rate (or the fraction of LRUs that break per flying hour at offshore bases) is the product of this number and the offshore demand rate multiplier from the VTM record group.
48-52	XXXxx	Lone base repair time (in days). Repair time at bases not served by a CIRF.
54-57	XXxx	Lone base NRTS rate. Fraction of removals at bases not served by a CIRF that are declared NRTS.
59-62	XXxx	Lone base percentage of NRTS to contractor. The percentage of items arriving at the depot from bases not served by a CIRF that go to the contractor for repair.
63-67	XXXxx	CIRF-served base repair time (in days). Repair time at bases served by a CIRF.
69-72	XXxx	CIRF-served base NRTS rate. Fraction of removals at bases served by a CIRF that are declared NRTS.
74-77	XXxx	CIRF-served base percentage of NRTS to contractor. The percentage of items arriving at the depot from bases served by a CIRF that go to the contractor for repair.

Second record of pair:

Columns	Format	
1-16	a16	LRU name. The name of the LRU. Must match LRU name given on first record of pair.

Columns	Format	
18-21	XXxx	CIRF repair time (in days). Repair time at CIRFs.
23-26	XXxx	CIRF NRTS rate. Fraction of removals at CIRFs that are declared NRTS.
28-31	XXxx	CIRF percentage of NRTS to contractor. The percentage of items arriving at the depot from CIRFs that go to the contractor for repair.
32-36	XXXxx	Depot repair time (in days). Repair time at depots.
43-46	XXxx	Depot condemnation rate. Fraction of removals at the depot that are declared condemned.
47-51	XXXXx	Peacetime resupply time (in days). The expected time for the highest echelon repairing this part to procure a replacement during peacetime (prior to the first day of war as specified on the third TOP record).
52-56	XXXXx	Wartime resupply time (in days). The expected time for the highest echelon repairing this part to procure a replacement during wartime (which starts on the day specified on the third TOP record).
58-65	XXXXXXXX	Cost. Unit cost of the LRU.

Option Selection

Header record: OPT

General description:
These records define the options that generate Dyna-METRIC's reports and specify the parameters that further define the options.

```
Columns
         1
123456789012345

    iiiiiXXXxx
    |  |  Second parameter
    |  First parameter
    Option number
```

Detailed description:
Options and their associated parameter values are described below.

Columns	Format	
5-7	iii	Option number.
8-10	iii	First parameter.
11-15	XXXxx	Second parameter.

Option

11 Performance report.
Note: this report is given even if option 11 is not selected. Selecting this option overrides the default parameters.

Assess the capability of aircraft at each time of analysis. Reports (assuming full cannibalization) the predicted number of degraded aircraft and achieved sorties, the probability of achieving a specified aircraft level, the number of FMC aircraft at a minimum requested confidence level, and the probability of having less than a specified level of aircraft degraded because of component support. The first parameter is the percent of aircraft that may be degraded (0 to 100), which defaults to 0. It is also the target used if future aircraft availability is the scheduling policy selected in the TBED record group. The second parameter is the confidence level (between 0 and 1), which defaults to an unuseful 0.

Option

15 Detailed parts disposition.
Write a file of expected pipeline segment contents, intended to be massaged by SAS (or something similar) to produce a usable report. See Appendix A for the formats.

24 Contract system at the depot.
The first parameter gives the length of each scheduling period (in days). The second gives the number of periods in advance for which the contract is computed. The field for the second parameter is for a real variable; the model rounds to the nearest integer. If the second parameter is 0, the contract computed at the start of each period is for that period. If 1, the computed contract is for the period immediately following, etc. The contract system is used only during peacetime unless the depot scheduling switch on the TBED record is set to 3 (to enable it in wartime).

25 Lateral supply.
The first parameter specifies the number of days it takes to move an LRU from one base to another. The second parameter (truncated by the model) indicates the day on which lateral supply is first available. Cutoffs do not affect these pipelines. Lateral supply is permitted only between bases in the same theater.

Sortie Rates

Header record: SRTS

Restriction: Follow the BASE record group.

General description:
These records specify the average number of daily sorties required per aircraft at each base on each day. Aircraft at bases for which SRTS records are not given will fly no sorties.

```
Columns
         1         2         3         4
123456789012345678901234567890123456789012345678

aaaaXXXxiiiiXXXxiiiiXXXxiiiiXXXxiiiiXXXxiiiiXXXx
|   |   |   |   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   |   |   Sixth sortie rate
|   |   |   |   |   |   |   |   |   |   Day sixth rate starts
|   |   |   |   |   |   |   |   |   Fifth sortie rate
|   |   |   |   |   |   |   |   Day fifth rate starts
|   |   |   |   |   |   |   Fourth sortie rate
|   |   |   |   |   |   Day fourth rate starts
|   |   |   |   |   Third sortie rate
|   |   |   |   Day third rate starts
|   |   |   Second sortie rate
|   |   Day second rate starts
|   First sortie rate
Base name
```

Detailed description:
Sortie rates may not exceed the base's maximum sortie rate entered in the TURN record group. The number of sortie rates is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than six levels follow the format of previous fields. Each day a sortie rate starts must be greater than the previous day.

For example, a record containing

```
BAS1  1. 158   3.
```

indicates that the aircraft at base BAS1 are required to average one daily sortie through day 157. Day 158 begins a new daily average of three sorties per aircraft that lasts throughout the scenario.

Columns	Format	
1-4	aaaa	Base name. The name of the base for which sortie requirements are specified. Must be named in the BASE record group. Enter at most one record per base.
5-8	XXXx	First sortie rate.
9-12	iiii	Day second rate starts.
13-16	XXXx	Second sortie rate.
17-20	iiii	Day third rate starts.
21-24	XXXx	Third sortie rate.
25-28	iiii	Day fourth rate starts.
29-32	XXXx	Fourth sortie rate.
33-36	iiii	Day fifth rate starts.
37-40	XXXx	Fifth sortie rate.
41-44	iiii	Day sixth rate starts.
45-48	XXXx	Sixth sortie rate.

Stock Levels

Header record: STK

Restriction: Appear at most once per repair resource, following the LRU, TEST, TBED, and TPRT records associated with that resource.

General description:
These records specify each component's level of stock at the depots, CIRFs and bases.

Columns

```
         1         2         3         4
1234567890123456789012345678901234567890123456

aaaaaaaaaaaaaaaa aaaaiiiii aaaaiiiii aaaaiiiii
|                |   |     |   |     |   |
|                |   |     |   |     |   Third stock level
|                |   |     |   |     Third stock location
|                |   |     |   Second stock level
|                |   |     Second stock location
|                |   First stock level
|                First stock location
LRU name

           4       5         6         7    8
           7890123456789012345678901234567890

            aaaaiiiii aaaaiiiii aaaaiiiiiiiii
            |   |     |   |     |   |    |
            |   |     |   |     |   |    Day levels start
            |   |     |   |     |   Sixth stock level
            |   |     |   |     Sixth stock location
            |   |     |   Fifth stock level
            |   |     Fifth stock location
            |   Fourth stock level
            Fourth stock location
```

Detailed description:
Stock levels for up to six bases may be entered on a single record. If more are needed, multiple records are allowed.

Stock levels may be changed DMSTKLVI.-1 times throughout the scenario by including multiple records for the LRU and location. The new levels go into effect on the day levels start. Records must appear in ascending order of columns 77-80.

For example, the following records indicate show the stock levels of two parts at two bases. One stock level changes during the scenario (day 154), that of PART A at BAS1.

```
PART A          BAS1    1 BAS2    2                                  0
PART B          BAS1    4 BAS2    5                                  0
PART A          BAS1    7                                          154
```

Columns	Format	
1-16	a16	LRU name. Name of LRU to which the stock levels apply. Must be named in the LRU record group. Enter as many records as needed per part.
18-21	aaaa	First stock location. Name of location to which first stock level applies.
22-26	iiiii	First stock level. Stock assigned to the first location.
28-31	aaaa	Second stock location.
32-36	iiiii	Second stock level.
38-41	aaaa	Third stock location
42-46	iiiii	Third stock level.
48-51	aaaa	Fourth stock location.
52-56	iiiii	Fourth stock level.
58-61	aaaa	Fifth stock location.
62-66	iiiii	Fifth stock level.
68-71	aaaa	Sixth stock location.
72-76	iiiii	Sixth stock level.
77-80	iiii	Day levels start. Day on which the stock levels go into effect. Each day must be greater than or equal to the previous day on any prior stock record (all stock records must appear in ascending order based on value of this field).

Server Levels

Header record: TBED

Restriction: Appear once per repair resource, following the LRU and TEST records associated with that resource.

General description:
These records specify the number of available servers per repair resource at each location on each day. Locations for which TBED records are not entered are assigned no servers.

```
Columns
         1         2         3         4         5
123456789012345678901234567890123456789012345678901

aaaaiXxxxxXXXXXXXXXXiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
|   ||    |   |  |  |  |  |  |  |  |  |  |  |  |
|   ||    |   |  |  |  |  |  |  |  |  |  |  |  | Sixth server level
|   ||    |   |  |  |  |  |  |  |  |  |  |  | Day sixth starts
|   ||    |   |  |  |  |  |  |  |  |  |  | Fifth server level
|   ||    |   |  |  |  |  |  |  |  |  | Day fifth level starts
|   ||    |   |  |  |  |  |  |  |  | Fourth server level
|   ||    |   |  |  |  |  |  |  | Day fourth level starts
|   ||    |   |  |  |  |  |  | Third server level
|   ||    |   |  |  |  |  | Day third level starts
|   ||    |   |  |  |  | Second server level
|   ||    |   |  |  | Day second level starts
|   ||    |   |  | First server level
|   ||    |   | Resupply cutoff duration
|   ||    | Resupply cutoff
|   || Resupply time
|   |Backorder rate
|  Scheduling switch
Location name
```

Detailed description:
The maximum number of server levels is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than six levels follow the format of the previous fields. Each day a new level starts must be greater than the previous day. No server level should exceed DMSTANDS.

Servers may be test stands or some other repair resource whose quantity or availability may limit the number of components repaired in a given time period.

Columns	Format	
1-4	aaaa	Location name. The name of the location for which server levels are specified. Must be named in the BASE, CIRF or DEPT record group. Enter at most one record per location.
5	i	Scheduling switch. The scheduling policy for the repair resource's servers at this location. Applies to entire scenario unless option 24 is selected, in which case the depot uses the contract system during peacetime and what is specified here for wartime. 0 or blank - current aircraft availability (priority scheduling: select the LRU grounding the most aircraft). 1 - first come, first served. 2 - future aircraft availability (for depots only). Parameters are set on OPT record for option 11 and on DEPT record associated with first depot (regardless of whether that depot uses this policy). Do not use it if there is a CIRF in the analysis. 3 - contract system (for depots only). Peacetime scheduling must be contract system, too (select option 24--parameters chosen there). 4 - NRTS to a higher echelon all LRUs assigned to this type of repair resource (for the depot, condemn). 5 - unconstrained repair.
6-10	Xxxxx	Backorder rate. Expected number of module failures per operating day that cause a server to become partially mission capable (able to repair only a subset of the LRUs assigned to it).
11-14	XXXX	Resupply time. Average time at this location to obtain a replacement module for the repair resource because of a failure that caused a server to become partially mission capable.
15-17	XXX	Resupply cutoff. Day that resupply of modules for the repair resource at this location is cut off.
18-20	XXX	Resupply cutoff duration. Number of days resupply of modules for the repair resource at this location is cut off.

Columns	Format	
21-23	iii	First server level.
24-26	iii	Day second level starts.
27-29	iii	Second server level.
30-32	iii	Day third level starts.
33-35	iii	Third server level.
36-38	iii	Day fourth level starts.
39-41	iii	Fourth server level.
42-44	iii	Day fifth level starts.
45-47	iii	Fifth server level.
48-50	iii	Day sixth level starts.
51-53	iii	Sixth server level.

Repair Resource Availability

Header record: TEST

Restriction: Appear once per repair resource, following the LRU records associated with that resource.

General description:
These records describe the availability of different types of repair resources, such as test equipment, skilled personnel, and equipment disassembly fixtures.

```
Columns
         1         2         3         4
1234567890123456789012345678901234567890

aaaa           XXxxxXXxxxXXxxxXXxxxXXxxx
|              |    |    |    |    |
|              |    |    |    |    Five server availability
|              |    |    |    Four server availability
|              |    |    Three server availability
|              |    Two server availability
|              One server availability
Repair resource name
```

Detailed description:
The number of server availabilities is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than five (DMCHANGE - 1) availabilities follow the format of the previous fields.

Columns	Format	
1-4	aaaa	Repair resource name. The name of the repair resource. This may be any string of four characters as long as it is neither a keyword (such as "TEST") nor the name of another repair resource.
16-20	XXxxx	One server availability. Fraction of the time a server is up if only one server is stationed at a location.
21-25	XXxxx	Two server availability. Fraction of the time each server is up if two servers are stationed at a location.

Columns	Format	
26-30	XXxxx	Three server availability. Fraction of the time each server is up if three servers are stationed at a location.
31-35	XXxxx	Four server availability. Fraction of the time each server is up if four servers are stationed at a location.
36-40	XXxxx	Five server availability. Fraction of the time each server is up if five servers are stationed at a location.

Administrative Data

Header record: none

Restriction: Must appear first, preceding all other record groups.

General description:
These records provide general information about the input data, including a heading, times of analysis, and a switch for setting exponential or deterministic distributions for repair and transportation times. Also given are base, CIRF and depot administrative times, and seeds for the random number generator.

First record:

```
Columns
         1         2     6         7         8
12345678901234567890.....01234567890123456789O

aaaaaaaaaaaaaaaaaaaa.....aaaaaaaaaaaaaaaaaaaa
|
Heading
```

Columns Format

1-80	20a4	Heading. The heading appearing at the top of the output reports. May be any string of up to 80 characters.

Second record:

```
Columns
         1         2         3  5         6         7         8
123456789012345678901234567890...01234567890123456789012345678 90

iiXXXxxXXXxxXXXxx  Version 5.0  XXXxxx    XXXxxx iiii iiii i i
|||      |    |     |            |         |      |    |   | |
|||      |    |    Data set      |         |      |    |   | Depot
|||      |    |      version     |         |      |    |   |  distribution
|||      |   Depot administrative|         |      |    |  CIRF
|||      |      time             |         |      |    |    distribution
|||     CIRF administrative time |         |      |  Reserved
||Base administrative time       |         |    Number of trials
|Exponential repair switch       |    Contractor OST to CIRF
Cutoff direction switch         Contractor OST to base
```

Detailed description, second record:

Columns	Format	
1	i	Cutoff direction switch. Set to 1 if the cutoff parameters in the BASE and TRNS record groups apply to both forward and retrograde transportation. Set to 0 or blank if they apply to forward transportation only.
2	i	Exponential repair switch. Set to 1 if transportation and repair delays have an exponential distribution. Set to 0 or blank if they have a deterministic distribution.
3-7	XXXxx	Base administrative time. The deterministic delay (in days) for LRUs removed at the flight line prior to entering base-level repair. Warning: this is truncated to an integer.
8-12	XXXxx	CIRF administrative time. The deterministic delay (in days) for LRUs that have been NRTSed by the base, after arrival at the CIRF and prior to entering CIRF-level repair. Warning: this is truncated to an integer.
13-17	XXXxx	Depot administrative time. The deterministic delay (in days) for LRUs that have been NRTSed to the depot from bases and CIRFs, after arrival at the depot and prior to entering depot-level repair. Warning: this is truncated to an integer.
20-30	11a	Data set version. Must contain "Version 5.0".
50-55	XXXxxx	Contractor OST to base. The order and ship time (in days) from the contractor to the base.
60-65	XXXxxx	Contractor OST to CIRF. The order and ship time (in days) from the contractor to the CIRF.
67-70	iiii	Number of trials.

```
72-75  iiii   Reserved.  Leave blank.

   77  i      CIRF distribution switch
              Set to 0 or blank if the CIRF fills requisitions
              on a first come, first served basis.  Set to 1 if it
              does a priority computation and fills requisitions
              based on greatest need.

   79  i      Depot distribution switch.
              Set to 0 or blank if the depot fills requisitions
              on a first come, first served basis.  Set to 1 if it
              does a priority computation and fills requisitions
              based on greatest need.
```

Third record:

```
Columns
         1         2  7  8
12345678901234567890...7890

iiiiiiiiiiiiiiiiiiii...ii i
|   |   |   |   |      |
|   |   |   |   |      Twentieth random seed
|   |   |   |   |            .
|   |   |   |   |            .
|   |   |   |   Fifth random seed
|   |   |   Fourth random seed
|   |   Third random seed
|   Second random seed
First random seed
```

Detailed description, third record:

Random number seeds are needed for the various random number streams that control the generation of LRU removals, repair times, transportation times, NRTSing, etc. Specify 20 integer random number seeds of 4 columns each. Depending on the random number generator, seeds may be read in as real, or they may not all be used.

Fourth record:

```
Columns
          1         2
123456789012345678901234

iiiiiiiiiiiiiiiiiiiiiiii
|   |   |   |   |   |
|   |   |   |   |   Fifth time of analysis
|   |   |   |   Fourth time of analysis
|   |   |   Third time of analysis
|   |   Second time of analysis
|   First time of analysis
First day of war
```

Detailed description, fourth record:

Times of analysis are the days for which output reports are requested. The number of analysis times is limited by the value of DMANALYS, selected when the model was compiled. Extra fields for more than five times of analysis follow the format of the previous fields.

No two times of analysis should be the same. All times to the right of and including a zero time of analysis are ignored. However, times do not need to be in numerical order.

Columns	Format	
1-4	iiii	First day of war. Should be greater than zero. Need not be greater (or less) than the first time of analysis. Wartime resupply times go into effect on this day.
5-8	iiii	First time of analysis.
9-12	iiii	Second time of analysis.
13-16	iiii	Third time of analysis.
17-20	iiii	Fourth time of analysis.
21-24	iiii	Fifth time of analysis.

LRU Repair Assignments

Header record: TPRT

Restriction: Appear once per repair resource, following the LRU, TEST, and TBED records associated with that resource.

General description:
These records specify which LRUs are assigned to the repair resource named in the immediately preceding TEST record group.

```
Columns
         1
1234567890123456

aaaaaaaaaaaaaaaa
|
LRU name
```

Detailed description:

Columns	Format	
1-16	a16	LRU name. The name of the LRU assigned to the repair resource. Must be named in the LRU record group. Enter each LRU that applies to the repair resource.

Depot Transportation

Header record: TRNS

Restriction: Follow the DEPT and BASE record groups.

General description:
These records describe transportation resources connecting bases and CIRFs with depots. If a record is not entered for some base-depot or CIRF-depot pair, transportation between the two is assumed to be instantaneous and never cut off.

```
Columns
         1         2         3         4
12345678901234567890123456789012345678901

aaaa aaaa XXxxx XXxxx   XXXxx XXXxx XXXxx
|    |    |     |       |     |     |
|    |    |     |       |     |     Transportation cutoff duration
|    |    |     |       |     Transportation cutoff
|    |    |     |       Transportation start
|    |    |     Transportation time from depot
|    |    Transportation time to depot
|    Depot name
Base or CIRF name
```

Detailed description:
Transportation and cutoff parameters also apply to the retrograde (base/CIRF-to-depot) pipeline if the cutoff direction switch in the TOP record group is set.

Columns	Format	
1-4	aaaa	Base or CIRF name. The name of the base or CIRF. Must be named in the BASE or CIRF record group.
6-9	aaaa	Depot name. The name of the depot. Must be named in the DEPT record group.
11-15	XXXxx	Transportation time to depot. Base/CIRF-to-depot transportation time (in days).
17-21	XXXxx	Transportation time from depot. Depot-to-base/CIRF transportation time (in days).

Columns	Format	
25-29	XXXxx	Transportation start. Day transportation from the depot first becomes available.
31-35	XXXxx	Transportation cutoff. Day transportation from the depot is cut off.
37-41	XXXxx	Transportation cutoff duration. Number of days transportation is cut off from the depot.

Maximum Sortie Rates

Header record: TURN

Restriction: Follow the BASE record group.

General description:
These records specify, at each base, the maximum number of sorties a mission capable aircraft can fly per day on each day. Aircraft at bases for which TURN records are not given will fly no sorties.

```
Columns
         1         2         3         4
123456789012345678901234567890123456789012345678

aaaaXXXxiiiiXXXxiiiiXXXxiiiiXXXxiiiiXXXxiiiiXXXx
|   |   |   |   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   |   |   Sixth maximum sortie rate
|   |   |   |   |   |   |   |   |   |   Day sixth rate starts
|   |   |   |   |   |   |   |   |   Fifth maximum sortie rate
|   |   |   |   |   |   |   |   Day fifth rate starts
|   |   |   |   |   |   |   Fourth maximum sortie rate
|   |   |   |   |   |   Day fourth rate starts
|   |   |   |   |   Third maximum sortie rate
|   |   |   |   Day third rate starts
|   |   |   Second maximum sortie rate
|   |   Day second rate starts
|   First maximum sortie rate
Base name
```

Detailed description:
The number of sortie rates is limited by the value of DMCHANGE, selected when the model was compiled. Extra fields for more than six rates follow the format of the previous fields. Each day a new rate starts must be greater than the previous day.

For example, a record containing

```
BAS1 1. 158  3.
```

indicates that at base BAS1, a single aircraft can fly at most one sortie per day through day 157. Beginning on day 158 (and for the rest of the scenario), a single aircraft can fly up to 3 sorties per day.

Columns	Format	
1-4	aaaa	Base name. The name of the base for which the maximum sortie rates are specified. Must be named in the BASE record group. Enter at most one record per base.
5-8	XXXx	First maximum sortie rate.
9-12	iiii	Day second rate starts.
13-16	XXXx	Second maximum sortie rate.
17-20	iiii	Day third rate starts.
21-24	XXXx	Third maximum sortie rate.
25-28	iiii	Day fourth rate starts.
29-32	XXXx	Fourth maximum sortie rate.
33-36	iiii	Day fifth rate starts.
37-40	XXXx	Fifth maximum sortie rate.
41-44	iiii	Day sixth rate starts.
45-48	XXXx	Sixth maximum sortie rate.

Variance to Mean Data

Header record: VTM

Restriction: Appear at most once per repair resource, following the LRU records associated with that resource.

General description:
These records give an LRU's wartime demand rate multipliers, removal process variance to mean ratio, and the probability that a partially mission capable repair resource is able to repair it. LRUs for which VTM records are not given are assumed:

- to have wartime demand rates equal to peacetime demand rates
- to have a Poisson removal process
- reparable on a partially mission capable repair resource.

```
Columns
          1         2         3         4         5
12345...567890123456789012345678901234567890123456789012345678

aaaaa...aa    XXxx XXxx XXxx XXxx       XXxxxx XXxxxx
|              |    |    |    |          |      |
LRU name       |    |    |    |          |      Offshore sustained
               |    |    |    |          |          demand rate
               |    |    |    |         Onshore sustained demand rate
               |    |    |   Partial reparability
               |    |   Variance to mean ratio
               |   Offshore demand rate multiplier
              Onshore demand rate multiplier
```

Detailed description:

Columns	Format	
1-16	a16	LRU name. The name of the LRU. Must be named in the LRU record group. Enter at most one record per LRU.
20-23	XXxx	Onshore demand rate multiplier. A number multiplied by the initial onshore demand rate (in the LRU record group) to obtain the actual onshore demand rate.
25-28	XXxx	Offshore demand rate multiplier. A number multiplied by the initial offshore demand rate (in the LRU record group) to obtain the actual offshore demand rate.

Columns	Format	
30-33	XXxx	Variance to mean ratio. The variance to mean ratio of the LRU's removal process. A value between 0 and 1 implies removals under a binomial distribution; a value of 1 implies removals with a Poisson distribution; a value greater than 1 implies removals with a negative binomial distribution.
35-38	XXxx	Partial reparability. Fraction of the time that a partially mission capable repair resource is able to repair the LRU. It must be a number between 0 and 1.
46-51	XXxxxx	Onshore sustained demand rate. At onshore bases, the demand rate beginning on the day set in the sustained demand start time in the BASE record group. If that start time is blank or 0, the sustained demand rate does not go into effect.
53-58	XXxxxx	Offshore sustained demand rate. At offshore bases, the demand rate beginning on the day set in the sustained demand start time in the BASE record group. If that start time is blank or 0, the sustained demand rate does not go into effect.

Appendix C

SAMPLE INPUT--BASE CASE

```
Example 1 - Base case.
 1 1.0        1.0   Version 5.0                                      100       0
475115838531914735277523314775315527952714736793689114718527224388917427322977 23
 151 150 153 157 160 165 180
OPT
     11  0  .95
     15
DEPT
DPT1
BASE
MOB                                                                       2.0   1
COB1                                                                      2.0   1
COB2                                                                      2.0   1
COB3                                                                      2.0   1
PACF                                                                      0.0   2
TRNS
COB1 DPT1  2.0  2.0
COB2 DPT1  2.0  2.0
COB3 DPT1  2.0  2.0
MOB  DPT1  0.0  0.0
PACF DPT1  2.0  2.0
ACFT
COB1  24
COB2  24
COB3  24
MOB   72
PACF  72
SRTS
COB1 0.0 151 3.0 158 1.0
COB2 0.0 151 3.0 158 1.0
COB3 0.0 151 3.0 158 1.0
MOB  1.0 151 3.0 158 1.0
PACF 1.0 151 3.0 158 1.0
FLHR
COB1 1.5
COB2 1.5
COB3 1.5
MOB  1.5
PACF 1.5
TURN
COB1 1.0 151 3.0 158 1.0
COB2 1.0 151 3.0 158 1.0
COB3 1.0 151 3.0 158 1.0
MOB  1.0 151 3.0 158 1.0
PACF 1.0 151 3.0 158 1.0
```

```
LRU
74DD0          DPT1 1    1      .00035 .00035   .09 0.47
74DD0                        0.09
74DA0          DPT1 1    1      .01205 .01205   .49 0.12
74DA0                        0.49
74CA0          DPT1 1    1      .00683 .00683   .18 0.12
74CA0                        0.18
14FB0          DPT1 1    1      .00566 .00566   .20 0.19
14FB0                        0.20
14AD0          DPT1 1    1      .00240 .00240   .13 0.23
14AD0                        0.13
14AA0          DPT1 1    1      .00646 .00646   .29 0.20
14AA0                        0.29
14AG0          DPT1 1    1      .00210 .00210   .20 0.27
14AG0                        0.20
14AF0          DPT1 1    1      .00167 .00167   .15 0.19
14AF0                        0.15
VTM
74DD0               1.0  1.0  4.0 1.00
74DA0               1.0  1.0  4.0 1.00
74CA0               1.0  1.0  4.0 1.00
14FB0               1.0  1.0  4.0 1.00
14AD0               1.0  1.0  4.0 1.00
14AA0               1.0  1.0  4.0 1.00
14AG0               1.0  1.0  4.0 1.00
14AF0               1.0  1.0  4.0 1.00
TEST
CI            .790
TBED
DPT1                  5
TPRT
74DD0
74DA0
74CA0
14FB0
14AD0
14AA0
14AG0
14AF0
STK
74DD0          COB1     1 COB2     1 COB3     1 MOB     15 PACF    15
74DA0          COB1    20 COB2    20 COB3    20 MOB     26 PACF    26
74CA0          COB1    11 COB2    11 COB3    11 MOB     13 PACF    13
14FB0          COB1    11 COB2    11 COB3    11 MOB      4 PACF     4
14AD0          COB1     5 COB2     5 COB3     5 MOB     16 PACF    16
14AA0          COB1    12 COB2    12 COB3    12 MOB      8 PACF     8
14AG0          COB1     3 COB2     3 COB3     3 MOB     11 PACF    11
14AF0          COB1     3 COB2     3 COB3     3 MOB      7 PACF     7
```

Appendix D

SAMPLE OUTPUT--BASE CASE

```
Dyna-METRIC Version 5, the Simulation.  (October 1987)
Example 1 - Base case.

  100 trials requested.
Default mesh-size to be used.

CIRF distribution:   First Come, First Served
Depot distribution:  First Come, First Served

First day of war:  151
Unscaled times of analysis:  150  153  157  160  165  180

If DRIVE scheduling is selected, the following parameters will be used:
         - planning horizon of  1 days
         - computation done every  1 days
         - knowledge of future scenario assumed


Base MOB  is in theatre   1
Base COB1 is in theatre   1
Base COB2 is in theatre   1
Base COB3 is in theatre   1
Base PACF is in theatre   2

If DRIVE scheduling is selected, goal will be at most   0 percent E(NFMC).
Option 15 has been selected, and will generate
    a file of expected pipeline contents.

Base MOB  loses repair queue upon deployment.
Base COB1 loses repair queue upon deployment.
Base COB2 loses repair queue upon deployment.
Base COB3 loses repair queue upon deployment.
```

----------Resource CI ----------

Loc. DPT1, resource CI - priority scheduling.

Base MOB - Resource CI

Day	Expected NFMC	NFMC Variance	Worst LRU & Prob	2nd Worst & Prob
150	0.1500	0.7875	14FB0 0.040	
153	1.8900	8.2579	14FB0 0.235	14AA0 0.110
157	8.5900	31.2619	14FB0 0.620	14AA0 0.230
160	9.1300	31.0531	14FB0 0.660	14AA0 0.170
165	8.5400	30.5484	14FB0 0.605	14AA0 0.170
180	6.6400	32.5904	14FB0 0.425	14AA0 0.235

Base COB1 - Resource CI

Day	Expected NFMC	NFMC Variance	Worst LRU & Prob	2nd Worst & Prob
150	0.0000	0.0000		
153	0.4500	1.4675	14AG0 0.060	14AF0 0.050
157	1.5800	6.8436	14AG0 0.130	14AF0 0.070
160	1.5800	6.3436	14AG0 0.150	14AF0 0.090
165	1.6600	7.5244	14AG0 0.145	14AF0 0.125
180	1.8400	6.6144	14AF0 0.180	14AG0 0.100

Base COB2 - Resource CI

Day	Expected NFMC	NFMC Variance	Worst LRU & Prob	2nd Worst & Prob
150	0.0000	0.0000		
153	0.4900	2.7899	14AG0 0.070	14AF0 0.030
157	1.2700	4.8971	14AG0 0.150	14AF0 0.090
160	1.3000	4.7900	14AG0 0.150	14AF0 0.090
165	1.6500	5.5675	14AG0 0.160	14AF0 0.125
180	1.9100	8.7619	14AG0 0.175	14AF0 0.150

Base COB3 - Resource CI

Day	Expected NFMC	NFMC Variance	Worst LRU & Prob	2nd Worst & Prob
150	0.0000	0.0000		
153	0.7800	5.6516	14AF0	14AG0
			0.050	0.050
157	1.9400	11.9564	14AG0	14AF0
			0.135	0.095
160	1.9100	10.2219	14AG0	14AF0
			0.153	0.093
165	2.1400	10.1804	14AG0	14AF0
			0.160	0.115
180	2.0700	8.3051	14AG0	74DD0
			0.205	0.125

Base PACF - Resource CI

Day	Expected NFMC	NFMC Variance	Worst LRU & Prob	2nd Worst & Prob
150	0.5600	4.4864	14FB0	14AF0
			0.110	0.010
153	3.0900	11.8819	14FB0	14AA0
			0.478	0.133
157	9.7500	37.5875	14FB0	14AA0
			0.455	0.350
160	9.6100	35.5979	14FB0	14AA0
			0.460	0.385
165	9.2000	28.9000	14FB0	14AA0
			0.445	0.365
180	7.6400	33.2504	14FB0	14AA0
			0.480	0.250

Day	Probability of achieving 0% NFMC goal
150	0.84
153	0.09
157	0.00
160	0.00
165	0.00
180	0.02

Performance based on stock on hand on day 150.

Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
			Full cannibalization							
MOB	0	72	0.960	0.960	72	0.150	0.787	0.002	71.85	1.000
COB1	0	24	1.000	1.000	24	0.000	0.000	0.000	0.00	0.000
COB2	0	24	1.000	1.000	24	0.000	0.000	0.000	0.00	0.000
COB3	0	24	1.000	1.000	24	0.000	0.000	0.000	0.00	0.000
PACF	0	72	0.870	0.870	68	0.560	4.486	0.008	71.44	1.000
Total		216				0.710		0.003	143.29	

Performance based on stock on hand on day 153.

Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
			Full cannibalization							
MOB	0	72	0.620	0.620	64	1.890	8.258	0.026	210.33	3.000
COB1	0	24	0.840	0.840	21	0.450	1.467	0.019	70.65	3.000
COB2	0	24	0.860	0.860	20	0.490	2.790	0.020	70.53	3.000
COB3	0	24	0.790	0.790	21	0.780	5.652	0.033	69.66	3.000
PACF	0	72	0.280	0.280	62	3.090	11.882	0.043	206.73	3.000
Total		216				6.700		0.031	627.90	

Performance based on stock on hand on day 157.

Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
			Full cannibalization							
MOB	0	72	0.010	0.010	54	8.590	31.262	0.119	190.23	3.000
COB1	0	24	0.580	0.580	17	1.580	6.844	0.066	67.26	3.000
COB2	0	24	0.640	0.640	18	1.270	4.897	0.053	68.19	3.000
COB3	0	24	0.570	0.570	16	1.940	11.956	0.081	66.18	3.000
PACF	0	72	0.020	0.020	49	9.750	37.587	0.135	186.75	3.000
Total		216				23.130		0.107	578.61	

Performance based on stock on hand on day 160.

			Full cannibalization							
Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
MOB	0	72	0.040	0.040	52	9.130	31.053	0.127	62.87	1.000
COB1	0	24	0.560	0.560	17	1.580	6.344	0.066	22.42	1.000
COB2	0	24	0.610	0.610	18	1.300	4.790	0.054	22.70	1.000
COB3	0	24	0.560	0.560	15	1.910	10.222	0.080	22.09	1.000
PACF	0	72	0.010	0.010	53	9.610	35.598	0.133	62.39	1.000
Total		216				23.530		0.109	192.47	

Performance based on stock on hand on day 165.

			Full cannibalization							
Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
MOB	0	72	0.090	0.090	55	8.540	30.548	0.119	63.46	1.000
COB1	0	24	0.530	0.530	17	1.660	7.524	0.069	22.34	1.000
COB2	0	24	0.530	0.530	17	1.650	5.567	0.069	22.35	1.000
COB3	0	24	0.500	0.500	16	2.140	10.180	0.089	21.86	1.000
PACF	0	72	0.010	0.010	53	9.200	28.900	0.128	62.80	1.000
Total		216				23.190		0.107	192.81	

Performance based on stock on hand on day 180.

			Full cannibalization							
Base	Targ. NFMC	Total ACFT	Prob. < 0% NFMC	Prob. Achieve Sorties	FMC-95% Conf	E(NFMC)	Variance (NFMC)	Exp. % NFMC	E(Sorties)	Exp. sorties /ACFT
MOB	0	72	0.200	0.200	56	6.640	32.590	0.092	65.36	1.000
COB1	0	24	0.470	0.470	17	1.840	6.614	0.077	22.16	1.000
COB2	0	24	0.500	0.500	16	1.910	8.762	0.080	22.09	1.000
COB3	0	24	0.420	0.420	16	2.070	8.305	0.086	21.93	1.000
PACF	0	72	0.100	0.100	54	7.640	33.250	0.106	64.36	1.000
Total		216				20.100		0.093	195.90	

Appendix E

SIZING PARAMETERS

Sizing parameters limit the size of the problem that can be analyzed. They should be set to reasonable values for your system--large enough to be useful but small enough to run and save resources. The left column shows typical values that we set with a global change command within the text editor. Some of these parameters are not currently used but must be set nonetheless (usually to 1)--they are reserved for future model development.

585	DMAIRCFT	- The maximum number of aircraft (plus one) that may be stationed at a base on any day of the scenario.
8	DMANALYS	- The maximum number of times of analysis.
20	DMBASES	- The maximum number of bases to be analyzed.
8	DMCHANGE	- The maximum number of occasions that data such as sortie rates and aircraft levels may change during a scenario.
2	DMCIRFS	- The maximum number of CIRFs to be analyzed.
1	DMDEPOTS	- The maximum number of depots to be analyzed.
50.	DMEXPMAX	- A number such that exp(-DMEXPMAX) > 0 on your computer.
23	DMLOCS	- The maximum number of locations to be analyzed (DMBASES + DMCIRFS + DMDEPOTS).
25	DMLRUGRP	- The maximum number of LRUs that may be assigned to a single repair resource.
25	DMLRUTEQ	- Set to DMLRUGRP.
2000	DMLSTMAX	- Determines the length of the list of LRU repairs prepared for the depot when scheduling is based on future aircraft availability. Too short a list, and the repair resource may complete it and sit idle pending the preparation of a new list. Too long a list wastes computational resources. If DMLSTMAX is sufficiently large reported performance will not be sensitive to changes in the parameter value. Set to 1 if this

repair scheduling policy will not be used.

5 DMMISSNS - Not currently used. Set to 5.

20 DMMISTR - The maximum number of contract periods in a scenario.

27 DMOPTION - The maximum number of available program options.

100 DMPMFMAX - Determines the number of terms of the probability distribution of demands over the planning horizon for a given LRU at a given base that may be computed. The model's size is sensitive to this value and if set too small, the scheduling policy based on future aircraft availability will not function properly. A good value is probably two or three times the maximum value of

LRU demand rate x base NRTS rate x aircraft x sorties per day x flying hours per sortie x (planning horizon + depot-to-base transportation time)

Set to 1 if scheduling based on future aircraft availability will not be used.

27 DMPRTGRP - The maximum number of LRUs per repair resource, plus two (DMLRUGRP + 2).

1 DMSRUGRP - Not currently used. Set to 1.

1 DMSRULRU - Not currently used. Set to 1.

16 DMSTANDS - The maximum number of servers per repair resource that may be assigned to a single location.

3 DMSTKLVL - The maximum number of times stock levels can change in the scenario, plus one.

1 DMSUBGRP - Not currently used. Set to 1.

1 DMSUBS2S - Not currently used. Set to 1.

1 DMTEQTYP - Not currently used. Set to 1.

390 DMTIME - The maximum number of days in a scenario, including the peacetime run-in.

25 DMTQLRUS - Set to DMLRUGRP.

Appendix F

PREPROCESSOR INPUT SPECIFICATION

The input data set for the preprocessor has three parts. The first describes the repair resources, the second describes the modules, and the third contains a module-LRU essentiality matrix. A sample data set appears in Appendix G.

1. Repair Resource Data

For each type of repair resource, include a record such as:

```
RF      2  0.2208  10
aaaa iiii ff.ffff iii
```

Columns	Format	Description
1-4	aaaa	Name of repair resource.
6-9	iiii	Number of servers at this location.
11-17	ff.ffff	Server diagnosis time, in days. (If the LRU must start over from the beginning whenever its repair is interrupted because of a server failure, the diagnosis time should also reflect the expected lost LRU repair time, which is the weighted average LRU repair time.)
19-21	iii	Number of LRUs assigned to this repair resource.

The sample record is for the RF repair resource. There are two servers, with a server diagnosis time of 0.2208 days. Ten LRUs are assigned to the RF repair resource.

2. Module Data

Include a header card (required only to have "MOD " in the first four columns) followed by a record for each module, such as:

```
MOD                  MTBF STOCK  RESUPPLY   RF   CI   DI   PP
MODULE 1          333.000    1   20.000     1    1    1    1
aaaaaaaaaaaaaaaa fffff.fff iiii fffff.fff iiii iiii iiii ....
```

Columns	Format	Description
1-16	a16	Name of the module.
18-26	fffff.fff	Mean time between failures, in operating days.
28-31	iiii	Module stock level.
33-41	fffff.fff	Module resupply time, in days.
43-46	iiii	Quantity of the module on first resource type.
48-51	iiii	Quantity of the module on second resource type.
etc.		

The sample record is for MODULE 1, which has a mean lifetime of 333 days. Its stock level is one, resupply time is 20 days, and quantity per resource is one on each of the four types of repair resource.

3. Module-LRU Essentiality Matrix

Include a header card (required only to have "MTRX" in the first four columns) followed by a record for each module, *in the same order as the module data above,* such as:

```
MTRX             1234567890
POWER SUPPLY     1130111111
aaaaaaaaaaaaaaaa iiiiiiiiii
```

Columns	Format	Description
1-16	a16	Module name. (This field is *not* checked, so make sure the right module is named and matched to that in section 2.)
18	i	The number of this module that must be working for this resource to test LRU 1.
19	i	The number of this module needed to test LRU 2.
20	i	The number of this module needed to test LRU 3.
etc.		

The sample record is for a module named POWER SUPPLY. Three of this module must be operational to test LRU 3, while LRU 4 can be tested even if no POWER SUPPLY modules are operational. To test the remaining LRUs, at least one POWER SUPPLY module must be operational.

Appendix G

SAMPLE PREPROCESSOR INPUT DATA

PP	2	0.3842	0					
DI	2	0.4755	0					
RF	2	0.5830	0					
CI	5	0.5431	8					
MOD	MTBF	STK	RESUPPLY	PP	DI	RF	CI	
A_AAA	7560.5	1	14.0	1	1	1	1	
A_AAD	3780.3	0	14.0	1	1	1	1	
A_AAE/ADB	6520.3	0	14.0	2	2	2	1	
ACAFO/ADAFO	889.4	1	14.0	0	0	1	1	
A_AAH	15121.0	0	14.0	1	1	1	1	
A_AAJ	15121.0	0	14.0	1	1	1	1	
A_AAK	7560.5	5	14.0	1	1	1	1	
ADAAO	1040.3	2	14.0	0	0	0	1	
A_ABA	15121.0	0	14.0	1	1	1	1	
A_ABC	7560.5	0	14.0	1	1	1	1	
A_ABG	1890.1	3	14.0	1	1	1	1	
A_ABK	15121.0	0	14.0	1	1	1	1	
A_ABO	240.0	2	14.0	1	1	1	1	
A_ACA	15121.0	0	14.0	1	1	1	1	
A_ACB	7560.5	0	14.0	1	1	1	1	
A_ACD	5040.3	2	14.0	1	1	1	1	
A_ACO	1512.1	3	14.0	1	1	1	1	
A_ADC	15121.0	1	14.0	1	1	1	1	
A_ADO	1080.1	2	14.0	1	1	1	1	
A_AGB	1680.1	5	14.0	1	1	1	1	
A_AGO	1080.1	4	14.0	1	1	1	1	
A_AHB	15121.0	0	14.0	1	1	1	1	
A_AHO	15121.0	0	14.0	1	1	1	[illegible]	
A_AJA	560.0	2	14.0	1	1	1	1	
A_AJF	15121.0	2	14.0	1	1	1	1	
A_AJO	1080.1	1	14.0	1	1	1	1	
A_AKA	15121.0	0	14.0	1	1	1	1	
A_AKG	15121.0	4	14.0	1	1	1	1	
A_AKO	521.4	3	14.0	1	1	1	1	
A_ALO	7560.5	0	14.0	1	1	1	1	
ADBAO	4161.0	2	14.0	0	0	0	1	
ADBBB	4161.0	5	14.0	0	0	0	1	
ADBBO	520.1	4	14.0	0	0	0	1	
ADBCO	378.3	3	14.0	0	0	0	1	
ADBFA	297.2	3	14.0	0	0	0	1	
ADBFB	1040.3	3	14.0	0	0	0	1	
ADBFD	4161.0	0	14.0	0	0	0	1	
ADBFE	2080.5	0	14.0	0	0	0	1	
ADBFO	416.1	2	14.0	0	0	0	1	
ADBGA	4161.0	2	14.0	0	0	0	1	
PGM ASSY	17487.5	0	14.0	2	2	3	2	

ADBGB	416.1	6	14.0	0	0	0	1
ADBGO	594.4	1	14.0	0	0	0	1
20V/4A	4796.7	0	14.0	0	2	1	1
35V/15A	3436.5	0	14.0	2	0	3	4
ADBNA	4161.0	0	14.0	0	0	0	1
ADBNO	1387.0	0	14.0	0	0	0	1
ADCDB	693.5	3	14.0	0	0	0	1
ADCDD	231.2	2	14.0	0	0	0	1
FEED THRU	3100.0	0	14.0	2	1	1	1
A_CDG	1381.8	0	14.0	0	1	0	1
ADCDH	780.2	4	14.0	0	0	0	6
ADCDR	4161.0	0	14.0	0	0	0	1
SWITCH	477.8	21	14.0	2	2	2	3
A_CEA	635.5	12	14.0	8	8	5	8
A_CEJ	280.2	3	14.0	2	2	0	3
A_CEM	222.7	28	14.0	4	2	3	3
A_CER	540.0	6	14.0	1	1	1	1
A_CES	382.2	18	14.0	6	4	4	8
A_CFB	270.0	6	14.0	1	1	1	1
A_CGA	518.5	29	14.0	9	3	5	3
A_CGD	2372.1	4	14.0	0	3	0	6
A_CGK	169.9	14	14.0	1	1	1	1
A_CGL	343.7	18	14.0	2	2	2	2
A_CGN	260.7	13	14.0	1	1	1	1
A_CGP	1890.1	2	14.0	1	1	1	1
A_CGQ	3024.2	1	14.0	1	1	1	1
A_CGR	7560.5	4	14.0	1	1	1	1
A_CGS	1374.6	10	14.0	1	1	1	1
STD TBI	1336.4	8	14.0	3	4	3	3
A_CHA	808.7	9	14.0	3	6	3	1
A_CHB	323.5	11	14.0	3	6	3	1
A_CHN	604.8	7	14.0	1	1	1	1
A_CHP	495.6	12	14.0	6	1	1	2
A_CHS	302.7	20	14.0	2	3	2	2
ADCJA	832.2	5	14.0	0	0	0	1
ADCJB	594.4	2	14.0	0	0	0	1
100V DAC	1387.0	5	14.0	0	0	0	6
10V DAC	2340.6	5	14.0	0	0	0	9
A_CLC	2520.2	3	14.0	1	1	1	1
A_CLD	1512.1	1	14.0	1	1	1	1
A_CLH	5040.3	1	14.0	1	1	1	1
A_CLJ	15121.0	3	14.0	1	1	1	1
A_CLK	504.0	12	14.0	1	1	1	1
A_CMA	2283.1	7	14.0	3	4	2	3
ADDBO	4161.0	0	14.0	0	0	0	1
ADDED	2080.5	0	14.0	0	0	0	1
ADDEO	1387.0	0	14.0	0	0	0	1
ADDFE	4161.0	0	14.0	0	0	0	1
ADDHB	2080.5	0	14.0	0	0	0	1
ADDHG	4161.0	0	14.0	0	0	0	1
ADDHL	2080.5	0	14.0	0	0	0	1

ADDHO	4161.0	0	14.0	0	0	0	1
3 PHASE PS	1767.6	4	14.0	1	0	1	1
MTRX	12345678						
A_AAA	11111111						
A_AAD	11111111						
A_AAE/ADB	11111111						
ACAFO/ADAFO	00100000						
A_AAH	11111111						
A_AAJ	11111111						
A_AAK	11111111						
ADAAO	11111111						
A_ABA	11111111						
A_ABC	11111111						
A_ABG	11111111						
A_ABK	11111111						
A_ABO	11111111						
A_ACA	11111111						
A_ACB	11111111						
A_ACD	11111111						
A_ACO	11111111						
A_ADC	11111111						
A_ADO	11111111						
A_AGB	11111111						
A_AGO	11111111						
A_AHB	11111111						
A_AHO	11111111						
A_AJA	11111111						
A_AJF	11111111						
A_AJO	11111111						
A_AKA	11111111						
A_AKG	11111111						
A_AKO	11111111						
A_ALO	11111111						
ADBAO	00000011						
ADBBB	10010110						
ADBBO	10010110						
ADBCO	11111111						
ADBFA	00011100						
ADBFB	00011100						
ADBFD	00011100						
ADBFE	00011100						
ADBFO	00011100						
ADBGA	00001100						
PGM ASSY	10012000						
ADBGB	00001100						
ADBGO	00001100						
20V/4A	00011000						
35V/15A	13024122						
ADBNA	01000000						
ADBNO	01000000						
ADCDB	01100000						

ADCDD	01100000
FEED THRU	11011100
A_CDG	00111100
ADCDH	00064600
ADCDR	01111100
SWITCH	33333333
A_CEA	57823500
A_CEJ	02122300
A_CEM	23223200
A_CER	11111111
A_CES	88888887
A_CFB	00100100
A_CGA	22213100
A_CGD	11066600
A_CGK	11111100
A_CGL	22222200
A_CGN	11111100
A_CGP	11100000
A_CGQ	11111100
A_CGR	11111100
A_CGS	11100000
STD TBI	22332322
A_CHA	11111111
A_CHB	00001100
A_CHN	11111111
A_CHP	11111111
A_CHS	00200000
ADCJA	11111100
ADCJB	00011100
100V DAC	00062600
10V DAC	00190900
A_CLC	11111111
A_CLD	11111111
A_CLH	11111111
A_CLJ	11111111
A_CLK	11111111
A_CMA	03220000
ADDBO	00010000
ADDED	00000100
ADDEO	00000100
ADDFE	01000000
ADDHB	01000000
ADDHG	01000000
ADDHL	01000000
ADDHO	01000000
3 PHASE PS	01110100

Appendix H

SAMPLE PREPROCESSOR OUTPUT DATA

Dyna-METRIC Version 5 Backorder Rate and Effective Resupply Time Program

Stand	Number	Ex(Diagnosis Time)
PP	2	0.3842
DI	2	0.4755
RF	2	0.5830
CI	5	0.5431

Input data:

Module name	MTBF	stock	resupply	PP	DI	RF	CI
A_AAA	7560.500	1	14.000	1	1	1	1
A_AAD	3780.300	0	14.000	1	1	1	1
A_AAE/ADB	6520.300	0	14.000	2	2	2	1
ACAFO/ADAFO	889.400	1	14.000	0	0	1	1
A_AAH	15121.000	0	14.000	1	1	1	1
A_AAJ	15121.000	0	14.000	1	1	1	1
A_AAK	7560.500	5	14.000	1	1	1	1
ADAAO	1040.300	2	14.000	0	0	0	1
A_ABA	15121.000	0	14.000	1	1	1	1
A_ABC	7560.500	0	14.000	1	1	1	1
A_ABG	1890.100	3	14.000	1	1	1	1
A_ABK	15121.000	0	14.000	1	1	1	1
A_ABO	240.000	2	14.000	1	1	1	1
A_ACA	15121.000	0	14.000	1	1	1	1
A_ACB	7560.500	0	14.000	1	1	1	1
A_ACD	5040.300	2	14.000	1	1	1	1
A_ACO	1512.100	3	14.000	1	1	1	1
A_ADC	15121.000	1	14.000	1	1	1	1
A_ADO	1080.100	2	14.000	1	1	1	1
A_AGB	1680.100	5	14.000	1	1	1	1
A_AGO	1080.100	4	14.000	1	1	1	1
A_AHB	15121.000	0	14.000	1	1	1	1
A_AHO	15121.000	0	14.000	1	1	1	1
A_AJA	560.000	2	14.000	1	1	1	1
A_AJF	15121.000	2	14.000	1	1	1	1
A_AJO	1080.100	1	14.000	1	1	1	1
A_AKA	15121.000	0	14.000	1	1	1	1
A_AKG	15121.000	4	14.000	1	1	1	1
A_AKO	521.400	3	14.000	1	1	1	1
A_ALO	7560.500	0	14.000	1	1	1	1
ADBAO	4161.000	2	14.000	0	0	0	1
ADBBB	4161.000	5	14.000	0	0	0	1
ADBBO	520.100	4	14.000	0	0	0	1
ADBCO	378.300	3	14.000	0	0	0	1
ADBFA	297.200	3	14.000	0	0	0	1
ADBFB	1040.300	3	14.000	0	0	0	1

ADBFD	4161.000	0	14.000	0	0	0	1
ADBFE	2080.500	0	14.000	0	0	0	1
ADBF0	416.100	2	14.000	0	0	0	1
ADBGA	4161.000	2	14.000	0	0	0	1
PGM ASSY	17487.500	0	14.000	2	2	3	2
ADBGB	416.100	6	14.000	0	0	0	1
ADBG0	594.400	1	14.000	0	0	0	1
20V/4A	4796.700	0	14.000	0	2	1	1
35V/15A	3436.500	0	14.000	2	0	3	4
ADBNA	4161.000	0	14.000	0	0	0	1
ADBN0	1387.000	0	14.000	0	0	0	1
ADCDB	693.500	3	14.000	0	0	0	1
ADCDD	231.200	2	14.000	0	0	0	1
FEED THRU	3100.000	0	14.000	2	1	1	1
A_CDG	1381.800	0	14.000	0	1	0	1
ADCDH	780.200	4	14.000	0	0	0	6
ADCDR	4161.000	0	14.000	0	0	0	1
SWITCH	477.800	21	14.000	2	2	2	3
A_CEA	635.500	12	14.000	8	8	5	8
A_CEJ	280.200	3	14.000	2	2	0	3
A_CEM	222.700	28	14.000	4	2	3	3
A_CER	540.000	6	14.000	1	1	1	1
A_CES	382.200	18	14.000	6	4	4	8
A_CFB	270.000	6	14.000	1	1	1	1
A_CGA	518.500	29	14.000	9	3	5	3
A_CGD	2372.100	4	14.000	0	3	0	6
A_CGK	169.900	14	14.000	1	1	1	1
A_CGL	343.700	18	14.000	2	2	2	2
A_CGN	260.700	13	14.000	1	1	1	1
A_CGP	1890.100	2	14.000	1	1	1	1
A_CGQ	3024.200	1	14.000	1	1	1	1
A_CGR	7560.500	4	14.000	1	1	1	1
A_CGS	1374.600	10	14.000	1	1	1	1
STD TBI	1336.400	8	14.000	3	4	3	3
A_CHA	808.700	9	14.000	3	6	3	1
A_CHB	323.500	11	14.000	3	6	3	1
A_CHN	604.800	7	14.000	1	1	1	1
A_CHP	495.600	12	14.000	6	1	1	2
A_CHS	302.700	20	14.000	2	3	2	2
ADCJA	832.200	5	14.000	0	0	0	1
ADCJB	594.400	2	14.000	0	0	0	1
100V DAC	1387.000	5	14.000	0	0	0	6
10V DAC	2340.600	5	14.000	0	0	0	9
A_CLC	2520.200	3	14.000	1	1	1	1
A_CLD	1512.100	1	14.000	1	1	1	1
A_CLH	5040.300	1	14.000	1	1	1	1
A_CLJ	15121.000	3	14.000	1	1	1	1
A_CLK	504.000	12	14.000	1	1	1	1
A_CMA	2283.100	7	14.000	3	4	2	3
ADDB0	4161.000	0	14.000	0	0	0	1
ADDED	2080.500	0	14.000	0	0	0	1

ADDEO	1387.000	0	14.000	0	0	0	1
ADDFE	4161.000	0	14.000	0	0	0	1
ADDHB	2080.500	0	14.000	0	0	0	1
ADDHG	4161.000	0	14.000	0	0	0	1
ADDHL	2080.500	0	14.000	0	0	0	1
ADDHO	4161.000	0	14.000	0	0	0	1
3 PHASE PS	1767.600	4	14.000	1	0	1	1

Module essentiality matrix:

A_AAA	11111111
A_AAD	11111111
A_AAE/ADB	11111111
ACAFO/ADAFO	00100000
A_AAH	11111111
A_AAJ	11111111
A_AAK	11111111
ADAAO	11111111
A_ABA	11111111
A_ABC	11111111
A_ABG	11111111
A_ABK	11111111
A_ABO	11111111
A_ACA	11111111
A_ACB	11111111
A_ACD	11111111
A_ACO	11111111
A_ADC	11111111
A_ADO	11111111
A_AGB	11111111
A_AGO	11111111
A_AHB	11111111
A_AHO	11111111
A_AJA	11111111
A_AJF	11111111
A_AJO	11111111
A_AKA	11111111
A_AKG	11111111
A_AKC	11111111
A_ALO	11111111
ADBAO	00000011
ADBBB	10010110
ADBBO	10010110
ADBCO	11111111
ADBFA	00011100
ADBFB	00011100
ADBFD	00011100
ADBFE	00011100
ADBFO	00011100
ADBGA	00001100
PGM ASSY	10012000

ADBGB	00001100
ADBGO	00001100
20V/4A	00011000
35V/15A	13024122
ADBNA	01000000
ADBNO	01000000
ADCDB	01100000
ADCDD	01100000
FEED THRU	11011100
A_CDG	00111100
ADCDH	00064600
ADCDR	01111100
SWITCH	33333333
A_CEA	57823500
A_CEJ	02122300
A_CEM	23223200
A_CER	11111111
A_CES	88888887
A_CFB	00100100
A_CGA	22213100
A_CGD	11066600
A_CGK	11111100
A_CGL	22222200
A_CGN	11111100
A_CGP	11100000
A_CGQ	11111100
A_CGR	11111100
A_CGS	11100000
STD TBI	22332322
A_CHA	11111111
A_CHB	00001100
A_CHN	11111111
A_CHP	11111111
A_CHS	00200000
ADCJA	11111100
ADCJB	00011100
100V DAC	00062600
10V DAC	00190900
A_CLC	11111111
A_CLD	11111111
A_CLH	11111111
A_CLJ	11111111
A_CLK	11111111
A_CMA	03220000
ADDBO	00010000
ADDED	00000100
ADDEO	00000100
ADDFE	01000000
ADDHB	01000000
ADDHG	01000000
ADDHL	01000000

ADDHO	01000000
3 PHASE PS	01110100

Results for stand PP :

Backorder rate	:	0.00447374
Resupply time	:	10.68491650
Server availability (alpha)	:	0.94551468
Failure rate	:	0.15446073
Failure less backorder rate	:	0.14998700
Mean time between failures that are not backorders	:	6.66724444

Module name	MTBB	b.o. rate	resupply
A_AAA	100000.000	0.0000100	7.022
A_AAD	3780.300	0.0002645	14.000
A_AAE/ADB	6520.300	0.0001534	14.000
A_AAH	15121.000	0.0000661	14.000
A_AAJ	15121.000	0.0000661	14.000
A_AAK	100000.000	0.0000100	0.477
A_ABA	15121.000	0.0000661	14.000
A_ABC	7560.500	0.0001323	14.000
A_ABG	100000.000	0.0000100	1.669
A_ABK	15121.000	0.0000661	14.000
A_ABO	1767.264	0.0005658	5.186
A_ACA	15121.000	0.0000661	14.000
A_ACB	7560.500	0.0001323	14.000
A_ACD	100000.000	0.0000100	4.768
A_ACO	100000.000	0.0000100	3.616
A_ADC	100000.000	0.0000100	7.003
A_ADO	100000.000	0.0000100	4.779
A_AGB	100000.000	0.0000100	0.000
A_AGO	100000.000	0.0000100	0.477
A_AHB	15121.000	0.0000661	14.000
A_AHO	15121.000	0.0000661	14.000
A_AJA	17752.125	0.0000563	4.885
A_AJF	100000.000	0.0000100	0.000
A_AJO	8128.308	0.0001230	7.166
A_AKA	15121.000	0.0000661	14.000
A_AKG	100000.000	0.0000100	0.000
A_AKO	100000.000	0.0000100	3.659
A_ALO	7560.500	0.0001323	14.000
PGM ASSY	17487.500	0.0000572	14.000
35V/15A	3436.500	0.0002910	14.000
FEED THRU	3100.000	0.0003226	14.000
SWITCH	100000.000	0.0000100	0.000
A_CEA	100000.000	0.0000100	1.907
A_CEJ	2554.633	0.0003914	4.161
A_CEM	100000.000	0.0000100	0.000
A_CER	100000.000	0.0000100	0.477
A_CES	100000.000	0.0000100	0.000

A_CFB	100000.000	0.0000100	1.590
A_CGA	100000.000	0.0000100	0.000
A_CGK	100000.000	0.0000100	0.000
A_CGL	100000.000	0.0000100	0.000
A_CGN	100000.000	0.0000100	0.000
A_CGP	100000.000	0.0000100	4.729
A_CGQ	60913.133	0.0000164	7.059
A_CGR	100000.000	0.0000100	0.000
A_CGS	100000.000	0.0000100	0.954
STD TBI	100000.000	0.0000100	0.000
A_CHA	100000.000	0.0000100	0.000
A_CHB	100000.000	0.0000100	0.000
A_CHN	100000.000	0.0000100	0.000
A_CHP	100000.000	0.0000100	0.000
A_CHS	100000.000	0.0000100	0.000
A_CLC	100000.000	0.0000100	0.477
A_CLD	15615.940	0.0000640	7.119
A_CLH	100000.000	0.0000100	7.036
A_CLJ	100000.000	0.0000100	0.000
A_CLK	100000.000	0.0000100	0.954
A_CMA	100000.000	0.0000100	0.000
3 PHASE PS	100000.000	0.0000100	0.000

Results for stand DI :

Backorder rate	:	0.00470990
Resupply time	:	10.85093980
Server availability (alpha)	:	0.94082099
Failure rate	:	0.13699470
Failure less backorder rate	:	0.13228481
Mean time between failures that are not backorders	:	7.55944729

Module name	MTBB	b.o. rate	resupply
A_AAA	100000.000	0.0000100	7.022
A_AAD	3780.300	0.0002645	14.000
A_AAE/ADB	6520.300	0.0001534	14.000
A_AAH	15121.000	0.0000661	14.000
A_AAJ	15121.000	0.0000661	14.000
A_AAK	100000.000	0.0000100	0.477
A_ABA	15121.000	0.0000661	14.000
A_ABC	7560.500	0.0001323	14.000
A_ABG	100000.000	0.0000100	1.669
A_ABK	15121.000	0.0000661	14.000
A_ABO	1767.264	0.0005658	5.186
A_ACA	15121.000	0.0000661	14.000
A_ACB	7560.500	0.0001323	14.000
A_ACD	100000.000	0.0000100	4.768
A_ACO	100000.000	0.0000100	3.616
A_ADC	100000.000	0.0000100	7.003
A_ADO	100000.000	0.0000100	4.779

A_AGB	100000.000	0.0000100	0.000
A_AGO	100000.000	0.0000100	0.477
A_AHB	15121.000	0.0000661	14.000
A_AHO	15121.000	0.0000661	14.000
A_AJA	17752.125	0.0000563	4.885
A_AJF	100000.000	0.0000100	0.000
A_AJO	8128.308	0.0001230	7.166
A_AKA	15121.000	0.0000661	14.000
A_AKG	100000.000	0.0000100	0.000
A_AKO	100000.000	0.0000100	3.659
A_ALO	7560.500	0.0001323	14.000
PGM ASSY	17487.500	0.0000572	14.000
20V/4A	4796.700	0.0002085	14.000
FEED THRU	3100.000	0.0003226	14.000
A_CDG	1381.800	0.0007237	14.000
SWITCH	100000.000	0.0000100	0.000
A_CEA	100000.000	0.0000100	1.907
A_CEJ	2554.633	0.0003914	4.161
A_CEM	100000.000	0.0000100	0.000
A_CER	100000.000	0.0000100	0.477
A_CES	100000.000	0.0000100	0.000
A_CFB	100000.000	0.0000100	1.590
A_CGA	100000.000	0.0000100	0.000
A_CGD	100000.000	0.0000100	3.065
A_CGK	100000.000	0.0000100	0.000
A_CGL	100000.000	0.0000100	0.000
A_CGN	100000.000	0.0000100	0.000
A_CGP	100000.000	0.0000100	4.729
A_CGQ	60913.133	0.0000164	7.059
A_CGR	100000.000	0.0000100	0.000
A_CGS	100000.000	0.0000100	0.954
STD TBI	100000.000	0.0000100	0.000
A_CHA	100000.000	0.0000100	0.000
A_CHB	100000.000	0.0000100	0.000
A_CHN	100000.000	0.0000100	0.000
A_CHP	100000.000	0.0000100	0.000
A_CHS	100000.000	0.0000100	0.000
A_CLC	100000.000	0.0000100	0.477
A_CLD	15615.940	0.0000640	7.119
A_CLH	100000.000	0.0000100	7.036
A_CLJ	100000.000	0.0000100	0.000
A_CLK	100000.000	0.0000100	0.954
A_CMA	100000.000	0.0000100	0.000

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Results for stand RF  :
     Backorder rate                :    0.00404222
     Resupply time                 :   12.03724960
     Server availability (alpha):       0.93872988
     Failure rate                  :    0.11599617
     Failure less backorder rate:       0.11195394
     Mean time between failures that are not
       backorders                  :    8.93224430
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Module name	MTBB	b.o. rate	resupply
A_AAA	100000.000	0.0000100	7.022
A_AAD	3780.300	0.0002645	14.000
A_AAE/ADB	6520.300	0.0001534	14.000
A_AAH	15121.000	0.0000661	14.000
A_AAJ	15121.000	0.0000661	14.000
A_AAK	100000.000	0.0000100	0.477
A_ABA	15121.000	0.0000661	14.000
A_ABC	7560.500	0.0001323	14.000
A_ABG	100000.000	0.0000100	1.669
A_ABK	15121.000	0.0000661	14.000
A_ABO	1767.264	0.0005658	5.186
A_ACA	15121.000	0.0000661	14.000
A_ACB	7560.500	0.0001323	14.000
A_ACD	100000.000	0.0000100	4.768
A_ACO	100000.000	0.0000100	3.616
A_ADC	100000.000	0.0000100	7.003
A_ADO	100000.000	0.0000100	4.779
ACAFO/ADAFO	8524.624	0.0001173	7.129
A_AGB	100000.000	0.0000100	0.000
A_AGO	100000.000	0.0000100	0.477
A_AHB	15121.000	0.0000661	14.000
A_AHO	15121.000	0.0000661	14.000
A_AJA	17752.125	0.0000563	4.885
A_AJF	100000.000	0.0000100	0.000
A_AJO	8128.308	0.0001230	7.166
A_AKA	15121.000	0.0000661	14.000
A_AKG	100000.000	0.0000100	0.000
A_AKO	100000.000	0.0000100	3.659
A_ALO	7560.500	0.0001323	14.000
PGM ASSY	17487.500	0.0000572	14.000
20V/4A	4796.700	0.0002085	14.000
35V/15A	3436.500	0.0002910	14.000
FEED THRU	3100.000	0.0003226	14.000
SWITCH	100000.000	0.0000100	0.000
A_CEA	100000.000	0.0000100	1.907
A_CEM	100000.000	0.0000100	0.000
A_CER	100000.000	0.0000100	0.477
A_CES	100000.000	0.0000100	0.000
A_CFB	100000.000	0.0000100	1.590
A_CGA	100000.000	0.0000100	0.000
A_CGK	100000.000	0.0000100	0.000
A_CGL	100000.000	0.0000100	0.000
A_CGN	100000.000	0.0000100	0.000
A_CGP	100000.000	0.0000100	4.729
A_CGQ	60913.133	0.0000164	7.059
A_CGR	100000.000	0.0000100	0.000
A_CGS	100000.000	0.0000100	0.954
STD TBI	100000.000	0.0000100	0.000
A_CHA	100000.000	0.0000100	0.000
A_CHB	100000.000	0.0000100	0.000

A_CHN	100000.000	0.0000100	0.000
A_CHP	100000.000	0.0000100	0.000
A_CHS	100000.000	0.0000100	0.000
A_CLC	100000.000	0.0000100	0.477
A_CLD	15615.940	0.0000640	7.119
A_CLH	100000.000	0.0000100	7.036
A_CLJ	100000.000	0.0000100	0.000
A_CLK	100000.000	0.0000100	0.954
A_CMA	100000.000	0.0000100	0.000
3 PHASE PS	100000.000	0.0000100	0.000

Results for stand CI :

Backorder rate : 0.01148698
Resupply time : 12.00329690
Server availability (alpha): 0.91438824
Failure rate : 0.18388136
Failure less backorder rate: 0.17239438
Mean time between failures that are not backorders : 5.80065298

Module name	MTBB	b.o. rate	resupply
A_AAA	100000.000	0.0000100	7.022
A_AAD	3780.300	0.0002645	14.000
A_AAE/ADB	6520.300	0.0001534	14.000
ACAFO/ADAFO	8524.624	0.0001173	7.129
A_AAH	15121.000	0.0000661	14.000
A_AAJ	15121.000	0.0000661	14.000
A_AAK	100000.000	0.0000100	0.477
ADAAO	100000.000	0.0000100	4.720
A_ABA	15121.000	0.0000661	14.000
A_ABC	7560.500	0.0001323	14.000
A_ABG	100000.000	0.0000100	1.669
A_ABK	15121.000	0.0000661	14.000
A_ABO	1767.264	0.0005658	5.186
A_ACA	15121.000	0.0000661	14.000
A_ACB	7560.500	0.0001323	14.000
A_ACD	100000.000	0.0000100	4.768
A_ACO	100000.000	0.0000100	3.616
A_ADC	100000.000	0.0000100	7.003
A_ADO	100000.000	0.0000100	4.779
A_AGB	100000.000	0.0000100	0.000
A_AGO	100000.000	0.0000100	0.477
A_AHB	15121.000	0.0000661	14.000
A_AHO	15121.000	0.0000661	14.000
A_AJA	17752.125	0.0000563	4.885
A_AJF	100000.000	0.0000100	0.000
A_AJO	8128.308	0.0001230	7.166
A_AKA	15121.000	0.0000661	14.000
A_AKG	100000.000	0.0000100	0.000
A_AKO	100000.000	0.0000100	3.659

A_ALO	7560.500	0.0001323	14.000
ADBAO	100000.000	0.0000100	0.715
ADBBB	100000.000	0.0000100	0.000
ADBBO	100000.000	0.0000100	0.477
ADBCO	100000.000	0.0000100	3.609
ADBFA	100000.000	0.0000100	3.630
ADBFB	100000.000	0.0000100	0.715
ADBFD	4161.000	0.0002403	14.000
ADBFE	2080.500	0.0004807	14.000
ADBFO	32869.398	0.0000304	4.799
ADBGA	100000.000	0.0000100	0.715
PGM ASSY	17487.500	0.0000572	14.000
ADBGB	100000.000	0.0000100	0.000
ADBGO	5350.338	0.0001869	7.137
20V/4A	4796.700	0.0002085	14.000
35V/15A	3436.500	0.0002910	14.000
ADBNA	4161.000	0.0002403	14.000
ADBNO	1387.000	0.0007210	14.000
ADCDB	100000.000	0.0000100	3.536
ADCDD	6156.551	0.0001624	4.907
FEED THRU	3100.000	0.0003226	14.000
A_CDG	1381.800	0.0007237	14.000
ADCDH	100000.000	0.0000100	3.008
ADCDR	4161.000	0.0002403	14.000
SWITCH	100000.000	0.0000100	0.000
A_CEA	100000.000	0.0000100	1.907
A_CEJ	2554.633	0.0003914	4.161
A_CEM	100000.000	0.0000100	0.000
A_CER	100000.000	0.0000100	0.477
A_CES	100000.000	0.0000100	0.000
A_CFB	100000.000	0.0000100	1.590
A_CGA	100000.000	0.0000100	0.000
A_CGD	100000.000	0.0000100	3.065
A_CGK	100000.000	0.0000100	0.000
A_CGL	100000.000	0.0000100	0.000
A_CGN	100000.000	0.0000100	0.000
A_CGP	100000.000	0.0000100	4.729
A_CGQ	60913.133	0.0000164	7.059
A_CGR	100000.000	0.0000100	0.000
A_CGS	100000.000	0.0000100	0.954
STD TBI	100000.000	0.0000100	0.000
A_CHA	100000.000	0.0000100	0.000
A_CHB	100000.000	0.0000100	0.000
A_CHN	100000.000	0.0000100	0.000
A_CHP	100000.000	0.0000100	0.000
A_CHS	100000.000	0.0000100	0.000
ADCJA	100000.000	0.0000100	0.000
ADCJB	92682.672	0.0000108	4.760
100V DAC	100000.000	0.0000100	0.954
10V DAC	100000.000	0.0000100	0.000
A_CLC	100000.000	0.0000100	0.477

A_CLD	15615.940	0.0000640	7.119
A_CLH	100000.000	0.0000100	7.036
A_CLJ	100000.000	0.0000100	0.000
A_CLK	100000.000	0.0000100	0.954
A_CMA	100000.000	0.0000100	0.000
ADDBO	4161.000	0.0002403	14.000
ADDED	2080.500	0.0004807	14.000
ADDEO	1387.000	0.0007210	14.000
ADDFE	4161.000	0.0002403	14.000
ADDHB	2080.500	0.0004807	14.000
ADDHG	4161.000	0.0002403	14.000
ADDHL	2080.500	0.0004807	14.000
ADDHO	4161.000	0.0002403	14.000
3 PHASE PS	100000.000	0.0000100	0.000

Stand CI   LRU conditional probabilities:

LRU 1 = 0.7527
LRU 2 = 0.3737
LRU 3 = 0.6688
LRU 4 = 0.4699
LRU 5 = 0.4189
LRU 6 = 0.3843
LRU 7 = 0.7619
LRU 8 = 0.7619

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